

## ELECTRONIC SUPPLEMENTARY MATERIAL

**Table S1. Characteristics of excluded studies.**

Reason for exclusion	Study
Study focused on acute pain as opposed to chronic pain ( <i>n</i> = 4)	Mak 2014 [1]; Nieman 2014 [2]; Arnson 2013 [3]; Catalano 2012 [4]
Study did not measure pain as an outcome of vitamin D supplementation ( <i>n</i> = 25)	Mannstadt [5]; Hadji [6]; Randolph 2014 [7]; Burkiewicz 2012 [8]; Hansen 2012 [9]; Sovik 2011 [10]; Haworth 2011 [11]; Liu 2011 [12]; Garcia-Hernandez 2010 [13]; Wicherts 2011 [14]; Muratore 2010 [15]; Lyritis 2010 [16]; Soliman 2011 [17]; Markopoulos 2010 [18]; Bjorkman 2008 [19]; Diaz 2008 [20]; Torregrosa 2007 [21]; Arden 2006 [22]; Boonen 2006 [23]; Stengel 2005 [24]; Tekeoglu 2005 [25]; Benevolenskaia 2004 [26]; Kriesel 1999 [27]; Lyritis 1994 [28]; Abate 1994 [29]
Study design only ( <i>n</i> = 1)	Cao 2012 [30]
Study was not double blind ( <i>n</i> = 6)	Gopinath 2011 [31]; Kawate 2010 [32]; Ringe 2004 [33]; Ringe 2004 [34]; Dottori 1982 [35]; Wandless 1980 [36]
Study did not involve supplementation with vitamin D ( <i>n</i> = 4)	Singh 2012 [37]; Haworth 2001 [38]; Taube 1994 [39]; Ringe 1989 [40]
Study supplemented with vitamin D in combination with other treatment ( <i>n</i> = 37)	Meier 2014 [41]; Henry 2014 [42]; Chlebowski 2013 [43]; Chlebowski 2013 [44]; Forni 2012 [45]; Lalla 2012 [46]; Peichl 2011 [47]; Silverman 2012 [48]; Guan 2010 [49]; Belcaro 2010 [50]; Merlotti 2011 [51]; Ringe 2010 [52]; Li 2010 [53]; Tauchmanova 2009 [54]; Xu 2008 [55]; Hines 2009 [56]; Lindsay 2009 [57]; Ringe 2009 [58]; Krockner 2008 [59]; Lyles 2007 [60]; Ringe 2007 [61]; Sato 2006 [62]; Chevrel 2006 [63]; Seikaly 2005 [64]; Dominguez 2005 [65]; Valensi 2005 [66]; Ringe 2006 [67]; Cascella 2005 [68]; Papadokostakis 2005 [69]; Iwamoto 2003 [70]; Shiota 2001 [71]; Bennedbaek 2001 [72]; Ringe 2000 [73]; Peichl 1999 [74]; Meunier 1998 [75]; Agnusdei 1997 [76]; Grove 1981 [77]
Not all the participants in the study had chronic pain ( <i>n</i> = 1)	Osunkwo 2012 [78]

## REFERENCES

1. Mak JC, Klein LA, Finnegan T, Mason RS, Cameron ID. An initial loading-dose vitamin D versus placebo after hip fracture surgery: baseline characteristics of a randomized controlled trial (REVITAHIP). *BMC Geriatrics*. 2014;14:101.
2. Nieman DC, Gillitt ND, Shanely RA, Dew D, Meaney MP, Luo B. Vitamin D2 supplementation amplifies eccentric exercise-induced muscle damage in NASCAR pit crew athletes. *Nutrients*. 2013;6(1):63-75.

3. Arnon Y, Itzhaky D, Mosseri M, Barak V, Tzur B, Agmon-Levin N, et al. Vitamin D inflammatory cytokines and coronary events: a comprehensive review. *Clin Rev Allergy Immunol*. 2013;45(2):236-47.
4. Catalano A, Morabito N, Atteritano M, Basile G, Cucinotta D, Lasco A. Vitamin D reduces musculoskeletal pain after infusion of zoledronic acid for postmenopausal osteoporosis. *Calcif Tissue Int*. 2012;90(4):279-85.
5. Mannstadt M, Clarke BL, Vokes T, Brandi ML, Ranganath L, Fraser WD, et al. Efficacy and safety of recombinant human parathyroid hormone (1-84) in hypoparathyroidism (REPLACE): a double-blind, placebo-controlled, randomised, phase 3 study. *Lancet Diabetes Endocrinol*. 2013;1(4):275-83.
6. Hadji P, Kauka A, Ziller M, Birkholz K, Baier M, Muth M, et al. Effect of adjuvant endocrine therapy on hormonal levels in premenopausal women with breast cancer: the ProBONE II study. *Breast Cancer Res Treat*. 2014;144(2):343-51.
7. Randolph AG, Yip WK, Falkenstein-Hagander K, Weiss ST, Janssen R, Keisling S, et al. Vitamin D-binding protein haplotype is associated with hospitalization for RSV bronchiolitis. *Clin Exp Allergy*. 2014;44(2):231-7.
8. Burkiewicz CJ, Guadagnin FA, Skare TL, do Nascimento MM, Servin SC, de Souza GD. Vitamin D and skin repair: a prospective, double-blind and placebo controlled study in the healing of leg ulcers. *Rev Col Bras Cir*. 2012;39(5):401-7.
9. Hansen D. A randomised clinical study of alfacalcidol and paricalcitol. *Dan Med J*. 2012;59(2):B4400.
10. Sovik TT, Aasheim ET, Taha O, Engstrom M, Fagerland MW, Bjorkman S, et al. Weight loss, cardiovascular risk factors, and quality of life after gastric bypass and duodenal switch: a randomized trial. *Ann Intern Med*. 2011;155(5):281-91.

11. Haworth CS, Sharples L, Hughes V, Elkin SL, Hodson ME, Conway SP, et al. Multicentre trial of weekly risedronate on bone density in adults with cystic fibrosis. *J Cyst Fibros.* 2011;10(6):470-6.
12. Liu BX, Wang LP, Xu M, Huang CJ, Tang FY, Lou YM, et al. Postmenopausal osteoporosis of liver and kidney deficiency type treated with acupoint catgut embedding by stages. *Chinese Acupuncture & Moxibustion.* 2011;31(4):315-9.
13. Garcia-Hernandez P, Carranza-Lira S, Motta-Martinez E. Monthly ibandronate attachment to Mexican and Chilean women with osteoporosis, with or without a biofeedback strategy. *Ginecol Obstet Mex.* 2010;78(6):322-8.
14. Wicherts IS, Boeke AJ, van der Meer IM, van Schoor NM, Knol DL, Lips P. Sunlight exposure or vitamin D supplementation for vitamin D-deficient non-western immigrants: a randomized clinical trial. *Osteoporos Int.* 2011;22(3):873-82.
15. Muratore M, Quarta L, Calcagnile F, Quarta E. "Twice-a-month" clodronate 200 mg IM: a new dosing regimen and improved therapy adherence in the treatment of postmenopausal osteoporosis. *Adv Ther.* 2010;27(5):314-20.
16. Lyritis G, Marin F, Barker C, Pfeifer M, Farrerons J, Brixen K, et al. Back pain during different sequential treatment regimens of teriparatide: results from EUROFOR. *Curr Med Res Opin.* 2010;26(8):1799-807.
17. Soliman AT, Adel A, Wagdy M, Alali M, Aziz Bedair EM. Manifestations of severe vitamin D deficiency in adolescents: effects of intramuscular injection of a megadose of cholecalciferol. *J Trop Pediatr.* 2011;57(4):303-6.
18. Markopoulos C, Tzoracoleftherakis E, Polychronis A, Venizelos B, Dafni U, Xepapadakis G, et al. Management of anastrozole-induced bone loss in breast cancer patients with oral risedronate: results from the ARBI prospective clinical trial. *Breast Cancer Res.* 2010;12(2):R24.

19. Bjorkman M, Sorva A, Tilvis R. Vitamin D supplementation has no major effect on pain or pain behavior in bedridden geriatric patients with advanced dementia. *Aging Clin Exp Res.* 2008;20(4):316-21.
20. Diaz PR, Neira LC, Fischer SG, Teresa Torres MC, Milinarsky AT, Giadrosich VR, et al. Effect of 1,25(OH)<sub>2</sub>-vitamin D on bone mass in children with acute lymphoblastic leukemia. *J Pediatr Hematol Oncol.* 2008;30(1):15-9.
21. Torregrosa JV, Fuster D, Pedroso S, Diekmann F, Campistol JM, Rubi S, et al. Weekly risedronate in kidney transplant patients with osteopenia. *Transpl Int.* 2007;20(8):708-11.
22. Arden NK, Crozier S, Smith H, Anderson F, Edwards C, Raphael H, et al. Knee pain, knee osteoarthritis, and the risk of fracture. *Arthritis Rheum.* 2006;55(4):610-5.
23. Boonen S, Marin F, Mellstrom D, Xie L, Desai D, Krege JH, et al. Safety and efficacy of teriparatide in elderly women with established osteoporosis: bone anabolic therapy from a geriatric perspective. *J Am Geriatr Soc.* 2006;54(5):782-9.
24. Stengel SV, Kemmler W, Pintag R, Beeskow C, Weineck J, Lauber D, et al. Power training is more effective than strength training for maintaining bone mineral density in postmenopausal women. *J Appl Physiol.* 2005;99(1):181-8.
25. Tekeoglu I, Adak B, Budancamanak M, Demirel A, Ediz L. Comparison of cyclic and continuous calcitonin regimens in the treatment of postmenopausal osteoporosis. *Rheumatol Int.* 2005;26(2):157-61.
26. Benevolenskaia LI, Toroptsova NV, Nikitinskaia OA, Sharapova EP, Korotkova TA, Rozhinskaia L, et al. Vitrum osteomag in prevention of osteoporosis in postmenopausal women: results of the comparative open multicenter trial. *Ter Arkh.* 2004;76(11):88-93.
27. Kriesel JD, Spruance J. Calcitriol (1,25-dihydroxy-vitamin D<sub>3</sub>) coadministered with influenza vaccine does not enhance humoral immunity in human volunteers. *Vaccine.* 1999;17(15-16):1883-8.

28. Lyritis GP, Androulakis C, Magiasis B, Charalambaki Z, Tsakalagos N. Effect of nandrolone decanoate and 1-alpha-hydroxy-calciferol on patients with vertebral osteoporotic collapse. A double-blind clinical trial. *Bone Miner.* 1994;27(3):209-17.
29. Abate G, Taormina F, Brillante C, Fracalaglio L. The effects of the carbocalcitonin and arginine-lysine-lactose combination in senile involutional osteoporosis. *Minerva Med.* 1994;85(5):253-9.
30. Cao Y, Jones G, Cicuttini F, Winzenberg T, Wluka A, Sharman J, et al. Vitamin D supplementation in the management of knee osteoarthritis: study protocol for a randomized controlled trial. *Trials.* 2012;13:131.
31. Gopinath K, Danda D. Supplementation of 1,25 dihydroxy vitamin D3 in patients with treatment naive early rheumatoid arthritis: a randomised controlled trial. *Int J Rheum Dis.* 2011;14(4):332-9.
32. Kawate H, Ohnaka K, Adachi M, Kono S, Ikematsu H, Matsuo H, et al. Alendronate improves QOL of postmenopausal women with osteoporosis. *Clin Interv Aging.* 2010;5:123-31.
33. Ringe JD, Dorst A, Faber H, Schacht E, Rahlfs VW. Superiority of alfacalcidol over plain vitamin D in the treatment of glucocorticoid-induced osteoporosis. *Rheumatol Int.* 2004;24(2):63-70.
34. Ringe JD, Dorst A, Faber H, Ibach K. Alendronate treatment of established primary osteoporosis in men: 3-year results of a prospective, comparative, two-arm study. *Rheumatol Int.* 2004;24(2):110-3.
35. Dottori L, D'Ottavio D, Brundisini B. Calcifediol and calcitonin in the therapy of rheumatoid arthritis. A short-term controlled study. *Minerva Med.* 1982;73(43):3033-40.
36. Wandless I, Jarvis S, Evans JG, Aird EG, Stevens J. Vitamin D3 in osteoporosis. *Br Med J.* 1980;280(6227):1320.

37. Singh S, Cuzick J, Mesher D, Richmond B, Howell A. Effect of baseline serum vitamin D levels on aromatase inhibitors induced musculoskeletal symptoms: results from the IBIS-II, chemoprevention study using anastrozole. *Breast Cancer Res Treat.* 2012;132(2):625-9.
38. Haworth CS, Selby PL, Adams JE, Mawer EB, Horrocks AW, Webb AK. Effect of intravenous pamidronate on bone mineral density in adults with cystic fibrosis. *Thorax.* 2001;56(4):314-6.
39. Taube T, Kylmala T, Lamberg-Allardt C, Tammela TL, Elomaa I. The effect of clodronate on bone in metastatic prostate cancer. Histomorphometric report of a double-blind randomised placebo-controlled study. *Eur J Cancer.* 1994;30A(6):751-8.
40. Ringe JD. Glucocorticoid-induced osteoporosis. *Clin Rheumatol.* 1989;8(Suppl 2):109-15.
41. Meier C, Kraenzlin C, Friederich NF, Wischer T, Grize L, Meier CR, et al. Effect of ibandronate on spontaneous osteonecrosis of the knee: a randomized, double-blind, placebo-controlled trial. *Osteoporos Int.* 2014;25(1):359-66.
42. Henry D, Vadhan-Raj S, Hirsh V, von Moos R, Hungria V, Costa L, et al. Delaying skeletal-related events in a randomized phase 3 study of denosumab versus zoledronic acid in patients with advanced cancer: an analysis of data from patients with solid tumors. *Support Care Cancer.* 2014;22(3):679-87.
43. Chlebowski RT, Pettinger M, Johnson KC, Wallace R, Womack C, Mossavar-Rahmani Y, et al. Calcium plus vitamin D supplementation and joint symptoms in postmenopausal women in the women's health initiative randomized trial. *J Acad Nutr Diet.* 2013;113(10):1302-10.
44. Chlebowski RT, Cirillo DJ, Eaton CB, Stefanick ML, Pettinger M, Carbone LD, et al. Estrogen alone and joint symptoms in the Women's Health Initiative randomized trial. *Menopause.* 2013;20(6):600-8.
45. Forni GL, Perrotta S, Giusti A, Quarta G, Pitrolo L, Cappellini MD, et al. Neridronate improves bone mineral density and reduces back pain in beta-thalassaemia patients with

- osteoporosis: results from a phase 2, randomized, parallel-arm, open-label study. *Br J Haematol.* 2012;158(2):274-82.
46. Lalla RV, Choquette LE, Feinn RS, Zawistowski H, Latortue MC, Kelly ET, et al. Multivitamin therapy for recurrent aphthous stomatitis: a randomized, double-masked, placebo-controlled trial. *J Am Dent Assoc.* 2012;143(4):370-6.
  47. Peichl P, Holzer LA, Maier R, Holzer G. Parathyroid hormone 1-84 accelerates fracture-healing in pubic bones of elderly osteoporotic women. *J Bone Joint Surg Am.* 2011;93(17):1583-7.
  48. Silverman S, Viswanathan HN, Yang YC, Wang A, Boonen S, Ragi-Eis S, et al. Impact of clinical fractures on health-related quality of life is dependent on time of assessment since fracture: results from the FREEDOM trial. *Osteoporos Int.* 2012;23(4):1361-9.
  49. Guan YT, Cai LL, Ding HX, Chen GD, Hu Y. Clinical study on combination of multiple regimens in treatment of osteoporosis in perimenopause and postmenopausal women. *Zhonghua Fu Chan Ke Za Zhi.* 2010;45(8):571-4.
  50. Belcaro G, Cesarone MR, Cornelli U, Dugall M. MF Afragil(R) in the treatment of 34 menopause symptoms: a pilot study. *Panminerva Med.* 2010;52(2 Suppl 1):49-54.
  51. Merlotti D, Rendina D, Gennari L, Mossetti G, Gianfrancesco F, Martini G, et al. Comparison of intravenous and intramuscular neridronate regimens for the treatment of Paget disease of bone. *J Bone Miner Res.* 2011;26(3):512-8.
  52. Ringe JD, Dorst A, Farahmand P. Efficacy of strontium ranelate on bone mineral density in men with osteoporosis. *Arzneimittelforschung.* 2010;60(5):267-72.
  53. Li M, Xing XP, Zhang ZL, Liu JL, Zhang ZL, Liu DG, et al. Infusion of ibandronate once every 3 months effectively decreases bone resorption markers and increases bone mineral density in Chinese postmenopausal osteoporotic women: a 1-year study. *J Bone Miner Metab.* 2010;28(3):299-305.

54. Tauchmanova L, Guerra E, Pivonello R, De Martino MC, De Leo M, Caggiano F, et al. Weekly clodronate treatment prevents bone loss and vertebral fractures in women with subclinical Cushing's syndrome. *J Endocrinol Invest*. 2009;32(5):390-4.
55. Xu J, Zhao DB. A randomized controlled trial on calcitriol combined with xianling gubao for the treatment of pain caused by osteoporosis. *Zhongguo Gu Shang*. 2008;21(10):798-9.
56. Hines SL, Mincey BA, Sloan JA, Thomas SP, Chottiner E, Loprinzi CL, et al. Phase III randomized, placebo-controlled, double-blind trial of risedronate for the prevention of bone loss in premenopausal women undergoing chemotherapy for primary breast cancer. *J Clin Oncol*. 2009;27(7):1047-53.
57. Lindsay R, Miller P, Pohl G, Glass EV, Chen P, Krege JH. Relationship between duration of teriparatide therapy and clinical outcomes in postmenopausal women with osteoporosis. *Osteoporos Int*. 2009;20(6):943-8.
58. Ringe JD, Farahmand P, Faber H, Dorst A. Sustained efficacy of risedronate in men with primary and secondary osteoporosis: results of a 2-year study. *Rheumatol Int*. 2009;29(3):311-5.
59. Krockner D, Ullrich H, Buttgereit F, Perka C. Influence of adjuvant pain medication on quality of life in the treatment of postmenopausal osteoporosis. *Orthopade*. 2008;37(5):435-9.
60. Lyles KW, Colon-Emeric CS, Magaziner JS, Adachi JD, Pieper CF, Mautalen C, et al. Zoledronic acid and clinical fractures and mortality after hip fracture. *N Engl J Med*. 2007;357(18):1799-809.
61. Ringe JD, Farahmand P, Schacht E, Rozehnal A. Superiority of a combined treatment of Alendronate and Alfacalcidol compared to the combination of Alendronate and plain vitamin D or Alfacalcidol alone in established postmenopausal or male osteoporosis (AAC-Trial). *Rheumatol Int*. 2007;27(5):425-34.
62. Sato Y, Honda Y, Iwamoto J. Etidronate for fracture prevention in amyotrophic lateral sclerosis: a randomized controlled trial. *Bone*. 2006;39(5):1080-6.

63. Chevrel G, Schott AM, Fontanges E, Charrin JE, Lina-Granade G, Duboeuf F, et al. Effects of oral alendronate on BMD in adult patients with osteogenesis imperfecta: a 3-year randomized placebo-controlled trial. *J Bone Miner Res.* 2006;21(2):300-6.
64. Seikaly MG, Kopanati S, Salhab N, Waber P, Patterson D, Browne R, et al. Impact of alendronate on quality of life in children with osteogenesis imperfecta. *J Pediatr Orthop.* 2005;25(6):786-91.
65. Dominguez LJ, Galioto A, Ferlisi A, Alessi MA, Belvedere M, Putignano E, et al. Intermittent intramuscular clodronate therapy: a valuable option for older osteoporotic women. *Age Ageing.* 2005;34(6):633-6.
66. Valensi P, Le Devehat C, Richard JL, Farez C, Khodabandehlou T, Rosenbloom RA, et al. A multicenter, double-blind, safety study of QR-333 for the treatment of symptomatic diabetic peripheral neuropathy. A preliminary report. *J Diabetes Complications.* 2005;19(5):247-53.
67. Ringe JD, Faber H, Farahmand P, Dorst A. Efficacy of risedronate in men with primary and secondary osteoporosis: results of a 1-year study. *Rheumatol Int.* 2006;26(5):427-31.
68. Cascella T, Musella T, Orio F, Jr., Palomba S, Bifulco G, Nappi C, et al. Effects of neridronate treatment in elderly women with osteoporosis. *J Endocrinol Invest.* 2005;28(3):202-8.
69. Papadokostakis G, Katonis P, Damilakis J, Hadjipavlou A. Does raloxifene treatment influence back pain and disability among postmenopausal women with osteoporosis? *Eur Spine J.* 2005;14(10):977-81.
70. Iwamoto J, Takeda T, Ichimura S, Matsu K, Uzawa M. Effects of cyclical etidronate with alfacalcidol on lumbar bone mineral density, bone resorption, and back pain in postmenopausal women with osteoporosis. *J Orthop Sci.* 2003;8(4):532-7.
71. Shiota E, Tsuchiya K, Yamaoka K, Kawano O. Effect of intermittent cyclical treatment with etidronate disodium (HEBP) and calcium plus alphacalcidol in postmenopausal osteoporosis. *J Orthop Sci.* 2001;6(2):133-6.

72. Bennedbaek O, Viktor J, Carlsen KS, Roed H, Vinding H, Lundbye-Christensen S. Infants with colic. A heterogenous group possible to cure? Treatment by pediatric consultation followed by a study of the effect of zone therapy on incurable colic. *Ugeskr Laeger*. 2001;163(27):3773-8.
73. Ringe JD, Coster A, Meng T, Schacht E, Umbach R. Therapy of glucocorticoid-induced osteoporosis with alfacalcidol/calcium and vitamin D/calcium. *Z Rheumatol*. 2000;59(3):176-82.
74. Peichl P, Rintelen B, Kumpan W, Broll H. Increase of axial and appendicular trabecular and cortical bone density in established osteoporosis with intermittent nasal salmon calcitonin therapy. *Gynecol Endocrinol*. 1999;13(1):7-14.
75. Meunier PJ, Sebert JL, Reginster JY, Briancon D, Appelboom T, Netter P, et al. Fluoride salts are no better at preventing new vertebral fractures than calcium-vitamin D in postmenopausal osteoporosis: the FAVOStudy. *Osteoporos Int*. 1998;8(1):4-12.
76. Agnusdei D, Bufalino L. Efficacy of ipriflavone in established osteoporosis and long-term safety. *Calcif Tissue Int*. 1997;61(Suppl 1):S23-7.
77. Grove O, Halver B. Relief of osteoporotic backache with fluoride, calcium, and calciferol. *Acta Med Scand*. 1981;209(6):469-71.
78. Osunkwo I, Ziegler TR, Alvarez J, McCracken C, Cherry K, Osunkwo CE, et al. High dose vitamin D therapy for chronic pain in children and adolescents with sickle cell disease: results of a randomized double blind pilot study. *Br J Haematol*. 2012;159(2):211-5.