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Preventing Falls with Vitamin D

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Abstract

Falls are the number one cause for injury-related morbidity and mortality in West Virginia's seniors. Multiple independent variables contribute to the risk of a fall: previous falls, alterations in balance and vision, impairments in gait and strength, and medications most highly correlate with the risk for a fall. Vitamin D supplementation is emerging as an easy, safe and well-tolerated fall reduction/prevention strategy due to the beneficial effects on the musculoskeletal system with improvements in strength, function and navigational abilities. From meta-analysis data, maximal fall reduction benefit in seniors is achieved when correcting vitamin D deficiency and when using adjunctive calcium supplementation. It is therefore recommended that practitioners in our state screen for fall risks and consider the addition of supplementation protocols that provide sufficient vitamin D and calcium to our seniors.

Introduction

The May/June 2012 issue of this Journal highlighted that falls are the number one cause of injury-related morbidity and mortality in West Virginia (WV) senior citizens.¹ The prevalence of falls is strongly correlated with advancing age: 30% prevalence in > 65 years of age; 50% prevalence in > 80 years of age

with an increased risk of falls noted in institutionalized seniors.²⁻⁴ Since WV ranks second nationally for the percent of population ≥ 65 years of age, we are at greater risk for fall related injuries. Over 106,000 WV seniors will suffer at least one fall this year with up to 50% of these falls causing minor trauma (lacerations and bruises) and 10% resulting in major injuries (traumatic brain injury and fractures).^{5,6} Nationally, there has been a 50% increase in fall related injury hospitalizations from 2001-2008 with over 2.2 million emergency room visits and over 580,000 hospitalizations in 2009 with costs expected to soar to \$32.4 billion by 2020.^{5,7,8}

What is a fall and what increases the risk of a fall?

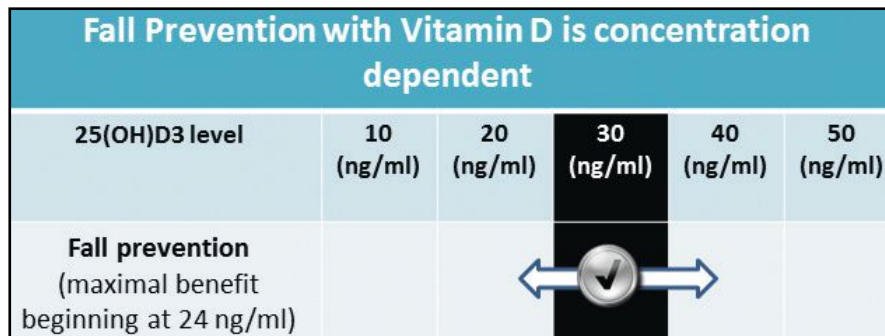
The World Health Organization defines a fall as the action of finding oneself involuntarily on the ground.² Identification of those most at risk for falls is critical. A screening summary was elegantly highlighted in this Journal.¹ Multiple independent variables contribute to the risk of a fall with previous falls, alterations in balance and vision, impairments in gait and strength, and medications most highly correlated with a fall.⁵ The more risk factors one has, the greater the risk of falls with some factors associated with a higher relative risk than others.⁵ Factors that double the risk of falling include alterations in vision, cognitive impairment, depression, age > 80 years old, and arthritis.⁹ Previous falls increase the risk of additional falls by 300% while lower-extremity muscle weakness increase the risk of falling by 400%.⁹ Because of the high correlation of falling with alterations in strength, gait and balance, vitamin D presents an emerging and effective approach to improve musculoskeletal strength, function and navigational abilities.

Economic analysis of fall prevention strategies has demonstrated that vitamin D replacement, in addition to medication reviews, were the most cost effective intervention to reduce falls.^{10,11}

What does vitamin D do to the musculoskeletal system?

Vitamin D has both direct genomic and non-genomic effects on skeletal muscle tissue. The receptor for vitamin D (VDR) is found in skeletal muscle (among various other tissues) which upon activation promotes *de novo* protein synthesis in muscle.¹² The proteins synthesized are responsible for events such as calcium influx and muscle fiber differentiation and proliferation.² Type II muscle fibers play a key role in falls because they are the first to be recruited when the body reacts to prevent a fall. Vitamin D deficiency can lead to muscle fiber atrophy, slow peak muscle contraction, prolonged time to relaxation and increased risk of chronic musculoskeletal pain.¹³⁻²¹ Deficient states have also been linked to generalized musculoskeletal pain, significant myopathy, muscle weakness, hypotonia and resultant gait abnormalities.^{21,22} Vitamin D supplementation can do the following: reverse the atrophy seen in Type II fibers decreasing fall risk by 20% in both institutionalized and non-institutionalized individuals, improve proximal muscle weakness and body sway associated with gait impairments, increase muscle strength/function and balance, reduce and reverse myalgias, and decrease muscle protein degradation.^{21,23-32} There is a dose-response relationship between serum 25(OH)D concentration and lower extremity function; higher 25(OH)D levels improve function.^{33,34} Studies have shown that in order to receive a fall protection benefit

Figure 1: Fall prevention with Vitamin D is concentration dependent with the most benefit obtained by correction of vitamin D deficiency defined as 25(OH)D < 30 ng/ml.



from supplementation, 25(OH)D levels need to be maintained above 24 ng/mL.^{23,24} These specific relationships and findings provide supportive evidence that vitamin D has a key role in muscle health and fall prevention.

In addition to the well-established effects of vitamin D on muscles it is also important to note the benefits of increased levels of vitamin D on the skeletal system, notably fracture reduction. A meta-analysis that will be discussed at length below showed that hip fractures can be reduced by 26% with vitamin D supplementation of 700-800 IU/day.³¹

Did supplementation increase 25(OH)D?

One critical concept is that any report on the efficacy of vitamin D supplementation as a fall prevention strategy should take into account the effect on the circulating form of vitamin D, 25-hydroxyvitamin D or 25(OH)D. 25(OH)D level is determined in ng/ml (or mmol/l) following a simple blood test with vitamin D deficiency defined as less than 30 ng/ml. Supplementation with vitamin D3 (cholecalciferol) instead of vitamin D2 (ergocalciferol) has shown to have a more significant effect on elevating 25(OH)D levels.³⁵ It is important to note that the cutaneous synthesis of vitamin D is less efficient as we age, so pharmacological protocols become very important in the senior demographic.³⁶

Meta-Analysis and Randomized Controlled Trials (RCT)

There are several key factors for reducing fall risk with vitamin D: (1) dosing protocol, (2) supplemental calcium and (3) baseline vitamin D status of participants.

Dosing matters

Dosing of vitamin D is a critical determinant in fall risk reduction and fracture prevention. Daily doses appear to be better than annual dosing strategies with daily doses of 700-1000 IU vitamin D per day reducing the number of falls by 19-26% in meta-analysis studies of randomized controlled trials.²⁵ However, no reduction in fall risk was shown when the vitamin D dose was 200-600 IU demonstrating a threshold effect for benefit. A serum 25(OH)D concentration of ≥ 24 ng/ml produced a 23% fall reduction with no reduction in falls noted for levels below 24 ng/ml (Figure 1). A subgroup analysis found that vitamin D3 was superior with a pooled relative risk reduction of 26% when compared to vitamin D2 (12% risk reduction). In a more recent meta-analysis of 11 double-blind, placebo controlled RCT with vitamin D with or without calcium in 31,022 patients >65 years of age, vitamin D supplementation of ≥ 800 IU daily produced a 30% reduction in the risk of hip fracture and a 14% reduction in the risk of nonvertebral fractures.³⁷ The American and British Geriatric

Societies have therefore produced guidelines that recommend 800 IU of daily vitamin D for all older adults at risk of falling.⁵ Annual dosing protocols of 500,000 IU vitamin D3 in a placebo-controlled trial of 2256 women >70 years of age actually increase the risk of falls by 15% with 26% more fractures than the placebo group.³⁸ Vitamin D deficiency is appropriately corrected with rapid supplementation protocols -- 50,000 IU vitamin D3 (Bio-Tech Pharmacal, Inc. Fayetteville, AR [12 capsules per bottle #36212A]) per week for 8 weeks in conjunction with daily dosing with repeat 25(OH)D testing in 3 months.³⁶ Of note, supplementation protocols can also use vitamin D2 for rapid supplementation with conversion to vitamin D3 for long term management.

Supplemental calcium and vitamin D status is important

A recent meta-analysis of 45,782 participants indicated that vitamin D use produced a statistically significant reduction in the risk of falls (Odds ratio for one fall 0.86) with a more prominent effect in patients with vitamin D deficiency and with calcium co-administration.³⁹ The optimal dose of vitamin D and calcium has not been established for maximal fall risk reduction but several promising RCT are in progress.^{40,41} One double-blind RCT worth highlighting studied 122 elderly women receiving either 1200 mg calcium + 800 IU Vit D or 1200 mg calcium per day for 12 weeks.²³ In this study 90% of patients were vitamin D deficient (< 31ng/ml) with the protocol increasing the 25(OH)D levels by 71% with a 49% reduction in falls in the calcium + vitamin D group when compared to calcium alone. Recurrent fallers benefitted most from this protocol. Of note, recent data indicates that vitamin D and calcium supplementation at levels used in this RCT do not promote kidney stone formation.^{42,43}

Conclusions

Falls are the number one cause of injury-related morbidity and mortality in West Virginia senior citizens. An excellent and cost effective strategy to improve muscle strength and reduce fall risk is supplementation with vitamin D and calcium. Data presented indicates that the most benefit in fall reduction is obtained in patients where vitamin D deficiency states are corrected (< 30ng/ml 25(OH)D) and with protocols that use at least 800 IU vitamin D3 per day with supplemental calcium. By implementation of these protocols, it is projected that a reduction of over 27,000 falls per annum can be realized in our senior population thus improving the quality of life, reducing the economic impact, and improving overall health of West Virginia seniors.

References

- Whiteman C, Davidov D, Tadros A, D'Angelo J. Falls and dilemmas in injury prevention in older West Virginians. *The West Virginia medical journal*. May-Jun 2012;108(3):14-20.
- Anweiler C, Montero-Odasso M, Schott AM, Berrut G, Fantino B, Beauchet O. Fall prevention and vitamin D in the elderly: an overview of the key role of the non-bone effects. *Journal of neuroengineering and rehabilitation*. 2010;7:50.
- Tinetti ME. Clinical practice. Preventing falls in elderly persons. *The New England journal of medicine*. Jan 2 2003;348(1):42-49.
- Kalyani RR, Stein B, Valiylil R, Manno R, Maynard JW, Crews DC. Vitamin D treatment for the prevention of falls in older adults: systematic review and meta-analysis. *Journal of the American Geriatrics Society*. Jul 2010;58(7):1299-1310.
- Bradley SM. Falls in older adults. *The Mount Sinai journal of medicine, New York*. Jul-Aug 2011;78(4):590-595.
- Werner CA, U.S. Census Bureau. The older population 2010. *2010 census briefs C2010BR-09*. Washington, D.C.: U.S. Dept. of Commerce Economics and Statistics Administration U.S. Census Bureau; 2011: <http://purl.fdlp.gov/GPO/gpo26266>
- <http://www.census.gov/prod/cen2010/briefs/c2010br-09.pdf>.
- Hartholt KA, Stevens JA, Polinder S, van der Cammen TJ, Patka P. Increase in fall-related hospitalizations in the United States, 2001-2008. *The Journal of trauma*. Jul 2011;71(1):255-258.
- Bischoff-Ferrari HA, Dawson-Hughes B, Willett WC, et al. Effect of Vitamin D on falls: a meta-analysis. *JAMA : the journal of the American Medical Association*. Apr 28 2004;291(16):1999-2006.
- Rubenstein LZ, Josephson KR. The epidemiology of falls and syncope. *Clinics in geriatric medicine*. May 2002;18(2):141-158.
- Noll DR. Management of falls and balance disorders in the elderly. *The Journal of the American Osteopathic Association*. Jan 2013;113(1):17-22.
- Church J, Goodall S, Norman R, Haas M. An economic evaluation of community and residential aged care falls prevention strategies in NSW. *New South Wales public health bulletin*. Jun 2011;22(3-4):60-68.
- Bischoff-Ferrari H, Stahelin HB, Walter P. Vitamin D effects on bone and muscle. *International journal for vitamin and nutrition research. Internationale Zeitschrift für Vitamin- und Ernährungsforschung. Journal international de vitaminologie et de nutrition*. Jul 2011;81(4):264-272.
- de Torrente de la Jara G, Pecoud A, Favrat B. Female asylum seekers with musculoskeletal pain: the importance of diagnosis and treatment of hypovitaminosis D. *BMC family practice*. 2006;7:4.
- Hamilton B. Vitamin D and human skeletal muscle. *Scandinavian journal of medicine & science in sports*. Apr 2010;20(2):182-190.
- Hicks GE, Shardell M, Miller RR, et al. Associations between vitamin D status and pain in older adults: the Invecchiare in Chianti study. *Journal of the American Geriatrics Society*. May 2008;56(5):785-791.
- Holick MF. Vitamin D deficiency: what a pain it is. *Mayo Clinic proceedings. Mayo Clinic*. Dec 2003;78(12):1457-1459.
- Houston DK, Cesari M, Ferrucci L, et al. Association between vitamin D status and physical performance: the InCHIANTI study. *The journals of gerontology. Series A, Biological sciences and medical sciences*. Apr 2007;62(4):440-446.
- Pfeifer M, Begerow B, Minne HW. Vitamin D and muscle function. *Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA*. Mar 2002;13(3):187-194.
- Plotnikoff GA, Quigley JM. Prevalence of severe hypovitaminosis D in patients with persistent, nonspecific musculoskeletal pain. *Mayo Clinic proceedings. Mayo Clinic*. Dec 2003;78(12):1463-1470.
- Rodman JS, Baker T. Changes in the kinetics of muscle contraction in vitamin D-depleted rats. *Kidney international*. Mar 1978;13(3):189-193.
- Stokes IAF, Oxford Orthopaedic Engineering Centre., Biological Engineering Society. *Mechanical factors and the skeleton*. London: Libbey; 1981.
- Ceglia L. Vitamin D and its role in skeletal muscle. *Current opinion in clinical nutrition and metabolic care*. Nov 2009;12(6):628-633.
- Bischoff HA, Stahelin HB, Dick W, et al. Effects of vitamin D and calcium supplementation on falls: a randomized controlled trial. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research*. Feb 2003;18(2):343-351.
- Dawson-Hughes B. Serum 25-hydroxyvitamin D and muscle atrophy in the elderly. *The Proceedings of the Nutrition Society*. Feb 2012;71(1):46-49.
- Bischoff-Ferrari HA, Dawson-Hughes B, Staehelin HB, et al. Fall prevention with supplemental and active forms of vitamin D: a meta-analysis of randomised controlled trials. *Bmj*. 2009;339:b3692.
- Ahmed W, Khan N, Glueck CJ, et al. Low serum 25 (OH) vitamin D levels (<32 ng/mL) are associated with reversible myositis-myalgia in statin-treated patients. *Translational research : the journal of laboratory and clinical medicine*. Jan 2009;153(1):11-16.
- Birge SJ, Haddad JG. 25-hydroxycholecalciferol stimulation of muscle metabolism. *The Journal of clinical investigation*. Nov 1975;56(5):1100-1107.
- Broe KE, Chen TC, Weinberg J, Bischoff-Ferrari HA, Holick MF, Kiel DP. A higher dose of vitamin D reduces the risk of falls in nursing home residents: a randomized, multiple-dose study. *Journal of the American Geriatrics Society*. Feb 2007;55(2):234-239.
- Pfeifer M, Begerow B, Minne HW, Abrams C, Nachtigall D, Hansen C. Effects of a short-term vitamin D and calcium supplementation on body sway and secondary hyperparathyroidism in elderly women. *Journal of bone and mineral research: the official journal of the American Society for Bone and Mineral Research*. Jun 2000;15(6):1113-1118.
- Pfeifer M, Begerow B, Minne HW, Suppan K, Fahrleitner-Pammer A, Dobnig H. Effects of a long-term vitamin D and calcium supplementation on falls and parameters of muscle function in community-dwelling older individuals. *Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA*. Feb 2009;20(2):315-322.
- Bischoff-Ferrari HA, Orav EJ, Dawson-Hughes B. Effect of cholecalciferol plus calcium on falling in ambulatory older men and women: a 3-year randomized controlled trial. *Archives of internal medicine*. Feb 27 2006;166(4):424-430.
- Wassner SJ, Li JB, Sperduto A, Norman ME. Vitamin D Deficiency, hypocalcemia, and increased skeletal muscle degradation in rats. *The Journal of clinical investigation*. Jul 1983;72(1):102-112.
- Wicherts IS, van Schoor NM, Boeke AJ, et al. Vitamin D status predicts physical performance and its decline in older persons. *The Journal of clinical endocrinology and metabolism*. Jun 2007;92(6):2058-2065.
- Bischoff-Ferrari HA, Dietrich T, Orav EJ, et al. Higher 25-hydroxyvitamin D concentrations are associated with better lower-extremity function in both active and inactive persons aged > or =60 y. *The American journal of clinical nutrition*. Sep 2004;80(3):752-758.
- Heaney RP. Functional indices of vitamin D status and ramifications of vitamin D deficiency. *The American journal of clinical nutrition*. Dec 2004;80(6 Suppl):1706S-1709S.
- Holick MF. Vitamin D deficiency. *The New England journal of medicine*. Jul 19 2007;357(3):266-281.
- Bischoff-Ferrari HA, Willett WC, Orav EJ, et al. A pooled analysis of vitamin D dose requirements for fracture prevention. *The New England journal of medicine*. Jul 5 2012;367(1):40-49.
- Sanders KM, Stuart AL, Williamson EJ, et al. Annual high-dose oral vitamin D and falls and fractures in older women: a randomized controlled trial. *JAMA : the journal of the American Medical Association*. May 12 2010;303(18):1815-1822.
- Murad MH, Elamin KB, Abu Elnour NO, et al. Clinical review: The effect of vitamin D on falls: a systematic review and meta-analysis. *The Journal of clinical endocrinology and metabolism*. Oct 2011;96(10):2997-3006.
- Uusi-Rasi K, Kannus P, Karinkanta S, et al. Study protocol for prevention of falls: a randomized controlled trial of effects of vitamin D and exercise on falls prevention. *BMC geriatrics*. 2012;12:12.
- Lopez-Torres Hidalgo J, Group A. Prevention of falls and fractures in old people by administration of calcium and vitamin D, randomized clinical trial. *BMC public health*. 2011;11:910.
- Heaney R. Vitamin D & Calcium, Fracture, & Kidney Stones -- What do we do? 2013. Accessed May 8, 2013 https://www.youtube.com/watch?v=T73Hwz5opag&feature=youtu e_gdata_player.