

The Importance of Maximizing Vitamin D in the Elderly Diet With Respect to Function and Falls

Heike A. Bischoff, MD, MPH, Robert B. Brigham, Arthritis and Musculoskeletal Diseases Clinical Research Center, Brigham and Women's Hospital and Division on Aging, Harvard Medical School; Boston, MA, USA.

There is increasing evidence that vitamin D supplementation may improve musculoskeletal function and prevent falls in older persons at risk for vitamin D deficiency. One basic concept appears to be the direct effect of vitamin D on muscle strength. Highly specific receptors for 1,25-dihydroxyvitamin D are expressed in human muscle tissue and it has been suggested that these nuclear receptors promote protein synthesis in the presence of 1,25-dihydroxyvitamin D, eventually leading to improved strength.

Key words: vitamin D, muscle strength, function, elderly, falls.

Introduction

Vitamin D and calcium supplementation has been found to be successful in reducing fracture risk in the elderly. Randomized controlled trials (RCT) reported a 58% decrease in the incidence of non-vertebral fractures with calcium and vitamin D supplementation in ambulatory elderly in the U.S.,¹ and a 43% reduction in the number of hip fractures in institutionalized elderly in France.² A recent five-year RCT documented a 33% reduction of any first hip, wrist or vertebral fracture in ambulatory elderly living in the U.K. with vitamin D supplementation alone.³ In the Nurses' Health Study, women consuming 500 IU or more of vitamin D per day from food plus supplements had a 37% lower risk of hip fracture (RR=0.63; 95% CI 0.42, 0.94) compared with women who consumed less than 500 IU per day.⁴

The protective effect of vitamin D on fractures has been attributed to the established moderate benefit of vitamin D on bone mineral density.^{1,5-8} However, an alternative explanation might be that vitamin D affects factors directly related to muscle strength, thus reducing fracture risk through improved function and fall prevention, in addition to its benefits on calcium homeostasis.

Evidence for Effects of Vitamin D on Muscle Tissue

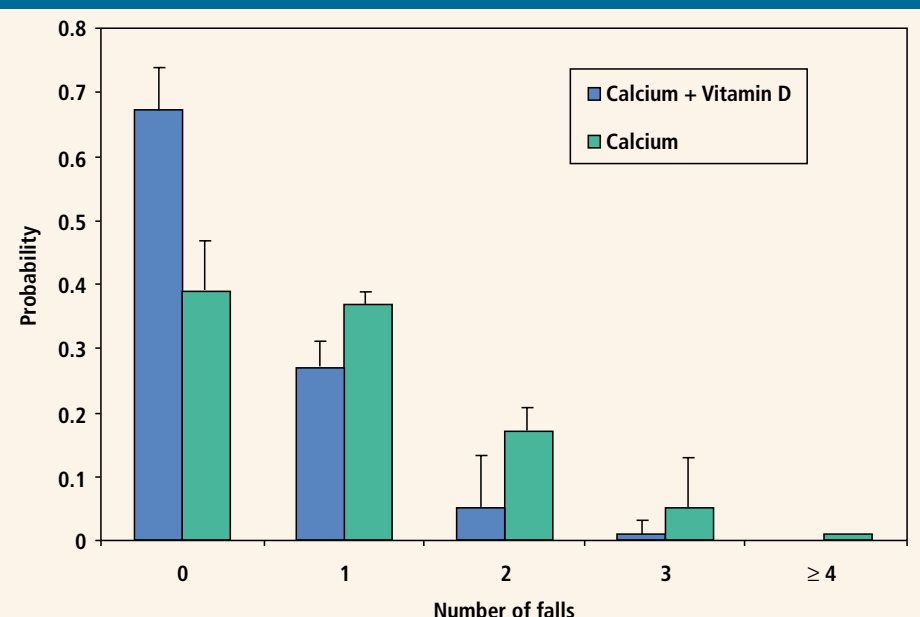
As both vitamin D deficiency and muscle weakness are common in the elderly, their association needs to be explored.⁹⁻¹¹ Several cross-sectional studies have demonstrated a beneficial effect of vitamin D on muscle strength, function or

balance. Low 25-hydroxyvitamin D levels have been documented in elderly fallers,¹² and leg extension power was significantly increased in ambulatory elderly men and women with higher 1,25-dihydroxyvitamin D levels.¹³ A randomized population survey found that in both hospitalized and ambulatory elderly, higher 25-hydroxyvitamin D levels were significantly correlated with better arm muscle strength, improved ability to climb stairs, higher physical activity and the absence of fall occurrences.¹⁴

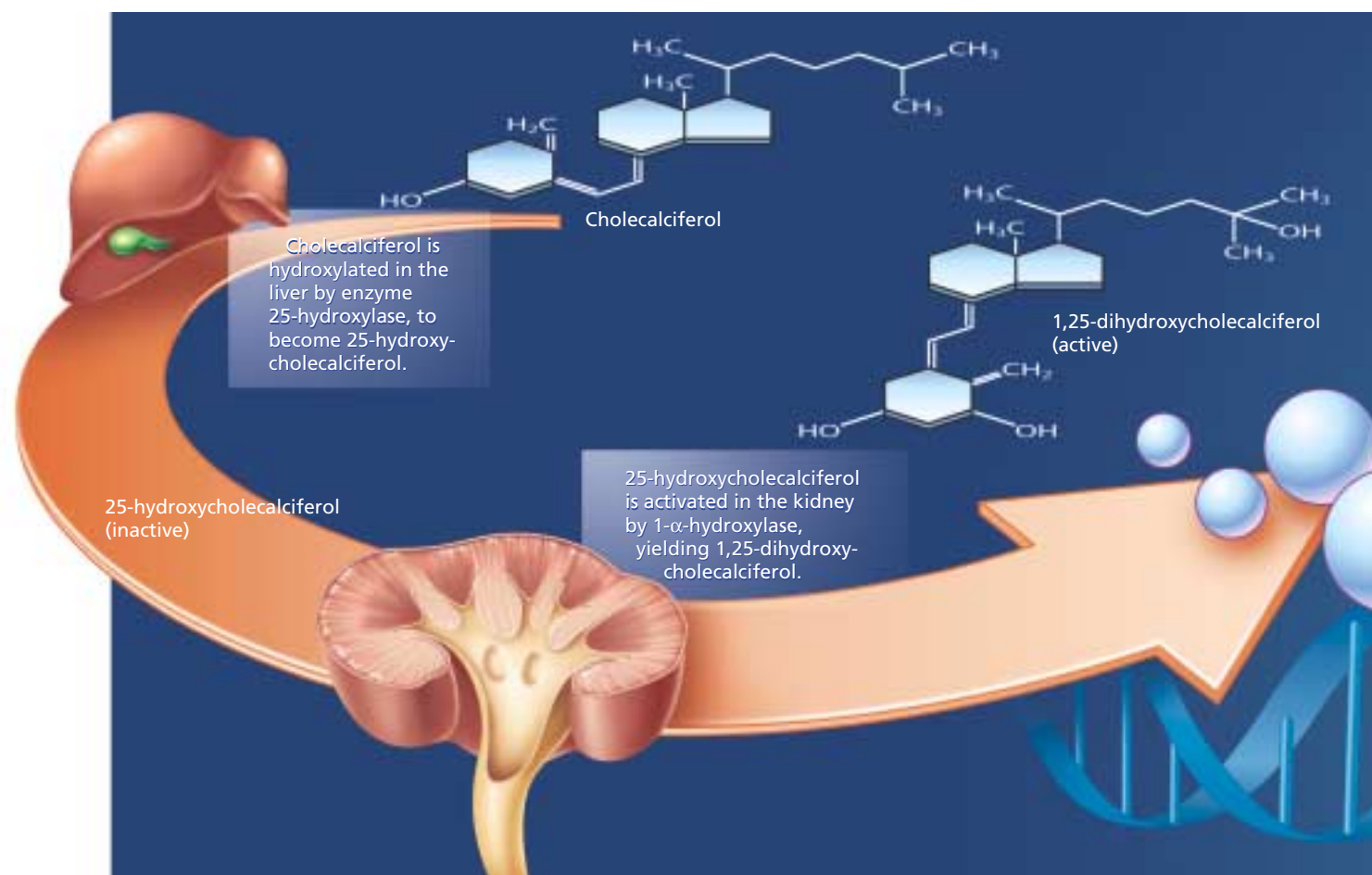
The positive associations between vitamin D and musculoskeletal function observed in cross-sectional studies are supported by two recent randomized controlled trials. In ambulatory elderly women, Pfeifer and colleagues found a decrease in body sway following a two-month treatment with vitamin D (800 IU per day) and calcium (1200mg per day),

Figure 1

Adjusted Probability of Having Zero, One or Multiple Falls Per Treatment Group



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as well as a reduction in falls within one year uncontrolled follow-up.¹⁵

Another RCT of institutionalized vitamin D-deficient elderly women randomized participants to either 800 IU vitamin D plus 1200mg calcium or 1200mg calcium alone per day. Vitamin D and calcium supplementation was found to significantly reduce fall risk by 49% (95% CI; $p < 0.01$) within 12 weeks compared with calcium alone.¹⁶ Figure 1 illustrates adjusted probabilities of having zero, one or multiple falls for subjects in both treatment groups, and indicates a reduced risk of falling once or repeatedly among subjects taking vitamin D plus calcium. The decrease in falls in the group that received vitamin D plus calcium may have been modulated by a significant improvement in musculoskeletal function observed in this study. Over time, women in the vitamin D plus calcium group had better grip strength, better knee extensor and flexor strength, and were quicker in the timed "up and go" test, a screening

and assessment tool for functional mobility of the older adult ($p = 0.0094$).

Role of Vitamin D on Muscle Function

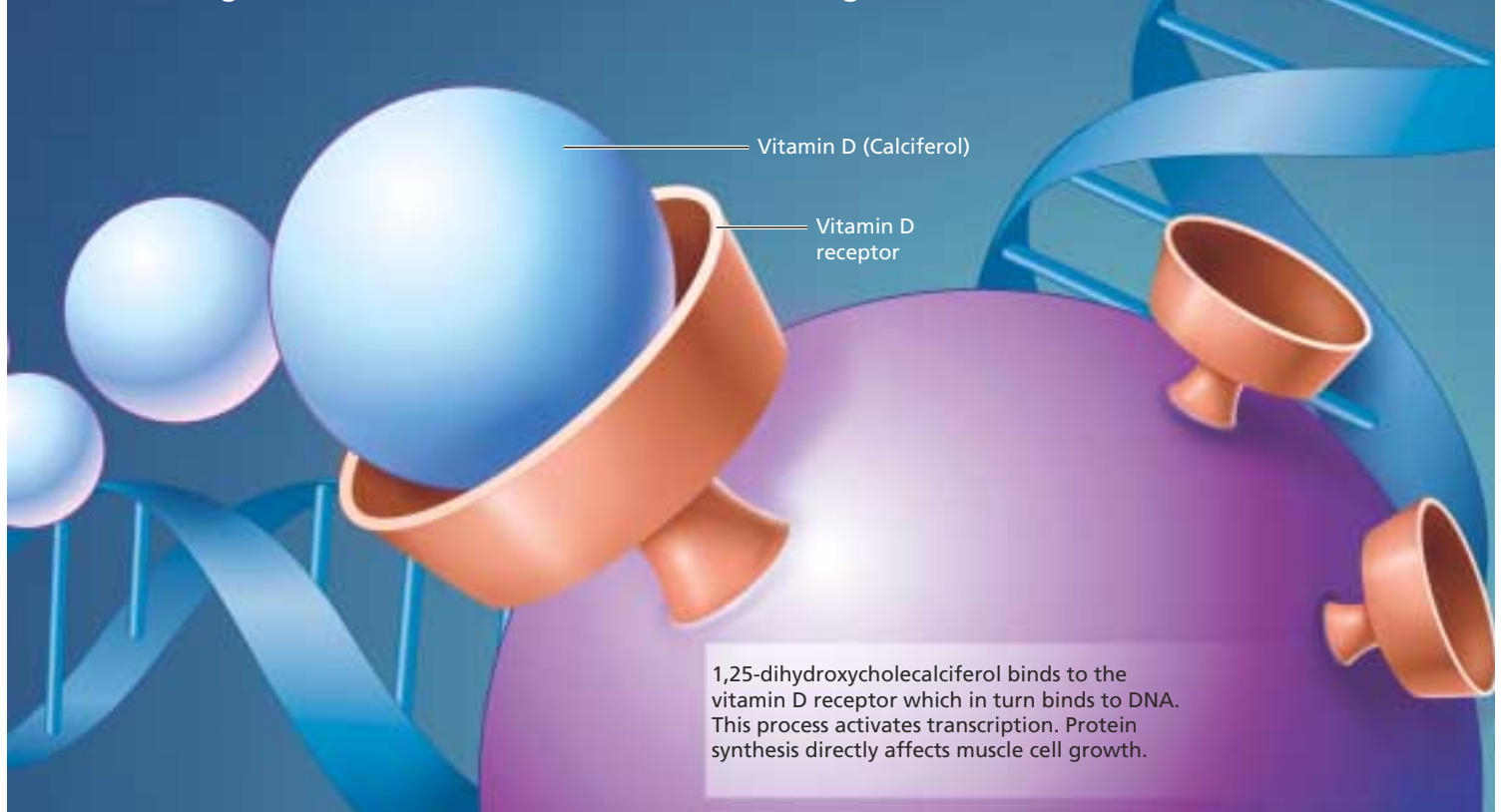
A possible explanation for the effect of vitamin D on muscle strength is that 1,25-hydroxyvitamin D, the active vitamin D metabolite, binds to a highly specific nuclear receptor in muscle tissue (Figure 2).^{17,18} It is currently believed that apart from rapid genome-independent calcium fluxes, 1,25-dihydroxyvitamin D elicits its biological response through the activation of the vitamin D receptor (VDR), which leads to de novo protein synthesis, affecting muscle cell growth.¹⁹ This is supported by a prospective study by Sorensen, *et al.*, which found an increase in the cross-sectional area and number of fast-twitch muscle fibres with 1 α -hydroxyvitamin D treatment (1 μ g per day) within three months in osteoporotic elderly women. This was accompanied by a clinical improvement of muscle function (time to dress).²⁰

Clinical Benefits of Vitamin D Supplementation

As its effect on muscle tissue appears to result in clinical improvement after short-term intervention,^{15,16,20} vitamin D is of major clinical interest for fall and fracture prevention in elderly people, especially if compared to the long-term intervention needed to enhance bone mineral density.^{1,2} In fact, Glerup, *et al.* suggested that vitamin D-deficient subjects show severely impaired muscle function prior to biochemical signs of bone disease.²¹ Repeated falling, usually occurring in the most frail elderly persons at the highest risk for hip fractures, may be most responsive to supplementation as these subjects have the highest risk for vitamin D deficiency.¹⁶

Improved muscle strength through vitamin D may also be important in osteoarthritis (OA) of the hip or knee, a major cause of disability in the elderly.²² Longitudinal studies suggest that muscle weakness not only results from painful joints, but that it is itself a risk factor for structural joint damage.²³ In fact, epidemi-

Figure 2: The Role of Vitamin D on Muscle Strength and Function



ological studies point toward an important role of vitamin D in OA prevention and progression without having established a potential mechanism. In the Framingham cohort study, risk of radiographic knee OA progression increased three-fold for participants in the middle and lower tertile of both vitamin D intake and serum levels.²⁴ In the Study of Osteoporotic Fractures, women in the lowest tertile of 25-hydroxyvitamin D levels were found to have an increased risk for development of hip OA.²⁵ At present, there are no intervention studies that have investigated the effect of vitamin D in osteoarthritis.

Conclusion

In summary, cross-sectional and intervention studies propose a beneficial effect of vitamin D on muscle strength, function and falls in institutionalized vitamin D-deficient elderly women.^{12-14,16,20} In addition, observational studies indicate similar benefits among ambulatory elderly women and men.^{13,14} However, this needs to be tested in prospective studies. Similarly, a potential

role of vitamin D in osteoarthritis needs to be explored in intervention studies.

In conclusion, vitamin D and calcium supplementation is a simple, inexpensive and well-tolerated intervention that may offer a way to reduce not only fractures, but the many distresses associated with declining function and falling in elderly persons. ♦

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