

Original article

# Effect of Serum 25(OH) vitamin D On Muscle Strength and Balance Over 65 Years of Age: A Cross Sectional Study

(Serum 25(OH) vitamin D düzeyinin kas kuvveti ve denge üzerine etkisi: 65 yaş üzeri popülasyonda kesitsel bir çalışma)

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## ÖZET

**Amaç:** Vitamin D'nin kırığa karşı koruyucu etkisi yanında, kas kuvvetini arttırarak düşmeleri azaltabileceği de bilinmektedir. Kesitsel çalışmalarda düşük serum 25 hidroksi vitamin D [25 (OH) D] seviyesinin kas kuvvetinde azalma, denge bozukluğu ve düşme riskinde artışla ilişkisi gösterilmiştir. Bu çalışmada, yaşlı popülasyonda, serum 25 (OH) D konsantrasyonu ile elin kavrama kuvveti ve denge arasındaki ilişkinin araştırılması ve klinik pratikte kuvvetinin vitamin D eksikliğine bağlı gelişen kas kuvvetsizliği ve düşme riskinin anlaşılmasında el kavrama kuvvetinin kullanılıp kullanılmayacağını araştırmak üzere planlandı.

**Materyal ve Metot:** Kesitsel olarak planlanan bu çalışmaya 65 yaş üstü, 53 katılımcı kabul edildi. Demografik özellikleri ve serum kalsiyum, fosfor, alkalin fosfat (ALP), 25 OH D ve paratiroid hormon düzeylerini kapsayan laboratuvar sonuçları değerlendirildi. Elin kavrama kuvveti, el dinamometresi ile, denge ise Berg Denge Skalası ile değerlendirildi.

**Bulgular:** 25 (OH) D düzeylerine göre 20 ng/mL'nin altında ve üstünde olarak iki gruba ayrılan katılımcıların el kavrama kuvvetleri ve Berg denge skalasının total skorları karşılaştırıldı. Berg denge skalası total skoru, 25 (OH) D düzeyi 20 ng/mL altında olan grupta diğer gruba göre istatistiksel olarak anlamlı derecede yüksek olarak saptandı (r:0,627, p=0,000). Ayrıca, 25 (OH) D düzeyi 20 ng/mL'nin üstünde olan hastaların kavrama kuvvetleri daha yüksek bulundu (p=0,023 and p=0,037, sırası ile dominant ve non-dominant eller için).

**Sonuçlar:** Bu çalışma Vitamin D'nin kas kuvveti, fonksiyonu ve denge üzerine önemli etkileri olduğunu desteklemektedir. Geriatri popülasyonunda vitamin D eksikliğini tedavisi kas kuvveti ve dengeyi düzelterek düşmelere de engel olacaktır.

**Anahtar Kelimeler:** Vitamin D; geriatri; Berg denge; kas kuvveti

## ABSTRACT

**Background:** Vitamin D has protective effect on fractures and improves muscle strength. Cross sectional studies have shown that low serum concentration of 25 hydroxy vitamin D[25 (OH) D] is related to decreased muscle strength, balance disorders and increased risk of falls. The purpose of this study was to assess the correlation between serum 25 (OH) D concentrations, grip strength and balance in older population to determine if grip strength could be used in clinical practice to estimate the risk of falls and muscle weakness secondary to vitamin D insufficiency.

**Materials and Methods:** Fifty three participants over 65 years of age were enrolled. Demographics and laboratory results including serum calcium, phosphorous, alkaline phosphatase, 25 (OH) vitamin D and parathyroid hormone concentrations were assessed. Hand grip strength was measured by a hand dynamometer. Berg balance scale was used for the assessment of balance.

**Results:** Grip strength and total score of Berg balance scale of participants with 25 (OH) vitamin D levels <20 ng/mL versus ≥20ng/mL were compared. Berg balance scale scores of patients with 25 (OH) D<20 ng/mL were higher than the other group (r:0.627, p=0.000). Participants with 25 (OH) D vitamin level of ≥20 ng/mL had higher grip strength compared to the other group (p=0.023 and p=0.037 for dominant and non-dominant hand respectively).

**Conclusions:** Vitamin D is essential for muscle strength and balance and therefore treatment of vitamin D deficiency reduce the incidence of falls in older population by improving muscle strength and balance.

**Key Words:** Vitamin D; geriatrics; Berg balance; muscle strength

## INTRODUCTION

Vitamin D, in addition to its well known protective effect on fracture, may also improve muscle strength

therefore reduce falls<sup>1</sup>. Many randomized controlled studies show that vitamin D supplementation decreases incidence of falls in older people. In a randomized controlled study, 800 IU/day vitamin D supplementation with 1200 mg/day calcium intake in older women had 4-11% improvement in musculoskeletal function compared to the ones taking same amount of calcium alone<sup>2</sup>.

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Vitamin D synthesis decreases in the older people. The prevalence of vitamin D insufficiency in people aged 65 years or older is estimated to be as high as 50%<sup>3</sup>. Serum 25 hydroxy vitamin D [25 (OH) D], a known indicator of nutritional vitamin D status, decreases with age<sup>4</sup>. Vitamin D insufficiency in older people is partly due to low sun light exposure and decreased ability of the aged skin to synthesize vitamin D3 in response to ultraviolet light<sup>5</sup>.

Low serum vitamin D concentration impairs muscle metabolism and muscle function. Long-term vitamin D deficiency results in severe muscle weakness<sup>6</sup>. Cross sectional studies have shown that low serum concentration of 25(OH) vitamin D is related to lower muscle strength and increased incidence of balance disorders and therefore increases the risk of falls. Longitudinal Aging Study Amsterdam has shown that, low serum 25(OH) vitamin D concentration and high serum PTH concentration were associated with loss of muscle strength and muscle mass during a 3 years of follow-up period<sup>7</sup>. In another study, a better lower extremity function was detected in patients with higher 25 (OH) D levels with a threshold value of 40 nmol/L<sup>8</sup>.

The purpose of this study was to determine the association between 25 (OH) vitamin D concentrations, grip strength and balance in the older population. If a correlation is proven to exist between these parameters, grip strength as an easy measurement of muscle strength can be routinely used in clinical practice to estimate the risk of falls secondary to vitamin D insufficiency induced muscle weakness.

## MATERIALS and METHODS

The study was approved by the institutional ethical committee of the University Hospital. In this cross-sectional study, 53 participants over 65 years of age referred to physical medicine and rehabilitation and neurology outpatient clinics were enrolled. Participation to the study was offered to all patients aged 65 years or older. Exclusion criteria included patients with previous cerebrovascular accidents, carpal tunnel syndrome, peripheral polyneuropathy, severe vitamin B12 (Vit B12) deficiency, severe osteoarthritis of the hand, knee or hip and severe spondylosis of cervical vertebra.

After gathering demographic data and past medical history, patients underwent baseline clinical examination. Grip strength was used as an indicator of muscle strength since it has been shown to correlate with both lower extremity and upper extremity strength in older people<sup>9</sup>. Hand

grip strength (in kilograms) was measured three times for each hand using a digital hand dynamometer (JAMAR®) and the average value was noted.

Venous blood samples were obtained from the participants and serum calcium (Ca), phosphorous (P), alkaline phosphatase (ALP), 25 (OH) vitamin D and parathyroid hormone (PTH) concentrations were measured.

Berg Balance Scale was used for evaluation of the postural control. Berg Balance Scale was translated to Turkish and has been studied for validity and reliability for Turkish population.<sup>10</sup> Berg Balance Scale includes 14 items to assess static sitting balance and standing balance, as well as balance during activities commonly performed in routine daily activities including, transfers, turning and retrieving objects from the floor.

Serum level of 25 (OH) D below 20 ng/mL has been accepted as the threshold value that inhibits secondary hyperparathyroidism and prevents bone resorption<sup>11</sup>. Therefore 20 ng/mL was accepted as the threshold value for 25(OH) vitamin D level in this study. Based on this, participants were divided into two groups according to their serum 25 (OH) D levels for statistical analysis: patients with 25 (OH) D levels <20 ng/mL and patients with 25 (OH) D levels ≥20 ng/mL.

The data was analyzed using "SPSS for Windows 18.0" program. Kolmogorov test was used to determine the distribution of continuous and intermittent variables. The data for serum Ca, P, Vit B12, 25 (OH) D, ALP, PTH levels and grip strength of dominant and non-dominant hand and the total score of Berg balance scale showed normal distribution, therefore these variables were assessed with parametric tests. Independent sample test was used to assess the significance of the difference between the clinical parameters among the groups. Pearson correlation test was used to determine the correlation between the groups. For all the statistical methods used in the study, p value of <0.05 was accepted as statistically significant at 95% confidence interval.

## RESULTS

Among the 53 participants, 38 (71.1%) were female and 15 (28.3%) were male. Demographic properties, clinical assessment and laboratory values are shown in Table 1. Only 3 patients had clinically insignificant osteoarthritis which did not interfere with the performance of Berg balance test. Out of 53 participants, 37 (69.8%) had 25(OH) D concentration <20 ng/mL. Among all 53 participants, no correlation was found between serum 25 (OH) D and the grip strength of

dominant ( $r:-0.100$   $p=0.478$ ) and non-dominant ( $r:-0.140$   $p=0.316$ ) hand. The correlation between the total score of Berg Balance test and 25 (OH) D levels was not strong or stronger than typical ( $r: 0.627$ ,  $p=0.000$ ). There was a much stronger than typical correlation between the grip strength of dominant and non-dominant hands ( $r:0.972$ ,  $p=0.000$ ). When the correlation between 25 (OH) D and the subscales of Berg balance scale were tested there was a medium or typical strong/stronger than typical correlation ( $p= 0.000$ ).

**Table 1.** Demographic Properties, Clinical and Laboratory Findings of the Participants (N:53)

Parameters	Mean $\pm$ SD	Range
Age (years)	72.43 $\pm$ 7.27	65-93
Weight (kg)	71.4 $\pm$ 13.35	43-106
Height (cm)	158.79 $\pm$ 8.74	143-180
BMI (kg/m <sup>2</sup> )	28.22 $\pm$ 4.64	21-39
Serum Ca (mg/dL)	9.45 $\pm$ 0.48	8.50-10.80
Serum P (mg/dL)	3.65 $\pm$ 0.59	2.58-4.71
Serum Vit B12 (pg/mL)	464.71 $\pm$ 218.14	220-1135
Serum 25 (OH) D (ng/mL)	16.02 $\pm$ 11.29	4.1-63.8
ALP (U/L)	78.56 $\pm$ 24.16	37.2-144.2
PTH (pg/mL)	77.35 $\pm$ 37.37	17-209
Grip strength of dominant hand (kg)	20.04 $\pm$ 7.47	10-40
Grip strength of non -dominant hand (kg)	17.93 $\pm$ 7.06	10-38
BERG balance test total score	40.66 $\pm$ 8.22	27-53

Patients with 25 (OH) vitamin D levels below and  $\geq 20$  ng/mL were compared with respect to the grip strength and total score of Berg balance scale. Patients with 25 (OH) vitamin D levels  $\geq 20$  ng/mL had stronger grip strengths in both hands compared with those of patients with 25 (OH) vitamin D levels below 20 ng/mL and the difference between these two groups were statistically significant ( $p=0.023$  and  $p=0.037$  respectively for dominant and non-dominant hand). When total scores of Berg Balance scale of two group of participants were compared, average scores of patients with 25 (OH) D  $<20$  ng/mL were higher than the average scores of patients with 25 (OH) D  $\geq 20$  ng/mL and this difference was statistically significant ( $p=0.000$ ) (Table 2).

**Table 2.** The Difference Between total Berg Scale Scores and Grip Strength of the Participants with 25 (OH) vitamin D levels

25 (OH) D concentration	N	Grip strength (Dominant hand, kg)		Grip strength (Nondominant hand, kg)		Total score of BERG scale	
		Mean $\pm$ SD	p	Mean $\pm$ SD	p	Mean $\pm$ SD	p
$<20$ ng/mL	37	17.06 $\pm$ 4.92	0.023	15.38 $\pm$ 4.56	0.037	36.43 $\pm$ 5.90	0.000
$\geq 20$ ng/mL	16	21.32 $\pm$ 8.05		19.04 $\pm$ 7.69		50.44 $\pm$ 2.06	

## DISCUSSION

Plasma 25 (OH) vitamin D measurements are at present considered to be the best method for describing nutritional vitamin D status in various risk groups, including older population. Several cross-sectional studies were done to determine a threshold in different populations based on an increased risk of secondary hyperparathyroidism, high bone turnover or low bone mineral density (BMD). For maximum calcium absorption and optimum calcium metabolism, serum 25 (OH) vitamin D level should be above 30 ng/mL. Serum level of 25 (OH) D below 20 ng/mL has been accepted as the threshold value that inhibits secondary hyperparathyroidism and prevents bone resorption<sup>11</sup>. Therefore 20 ng/mL was accepted as the threshold value of 25(OH) vitamin D in this study.

The prevalence of vitamin D insufficiency in people aged 65 years or older is estimated to be as high as 50%<sup>3</sup>. Vitamin D deficiency in older people is believed to be due to low sun light exposure and decreased ability of the aged skin to synthesize vitamin D3 in response to ultraviolet light<sup>5</sup>. In our study, 69.8% of the participants had serum 25(OH) vitamin D concentration  $<20$  ng/mL. This study was carried out during winter months in a city with cold climate causing minimal sun exposure at the time of the study, which may have contributed to the higher incidence vitamin D insufficiency in this age group. A limitation of our study was the sample size being small. However, the study was done in a University Hospital located in a metropolitan area with patients from different socioeconomic status. Therefore we believe that the sample in this study is composed of a heterogeneous group of participants and therefore is a good representation of the general population.

The role of vitamin D in the maintenance of bone health is well documented in various populations<sup>12,13</sup>. In addition to maintaining bone health, the effect of vitamin D on muscle strength has been subject to many studies. Clinically, vitamin D deficiency may cause muscle weakness and impaired physical function.

The association between muscle disease and low vitamin D level seems to be strong and symptoms related to poor muscle strength have been reported to respond well to vitamin D replacement. 1, 25(OH)<sub>2</sub> vitamin D receptors have been identified in skeletal muscle tissue. The quadriceps and grip strength differ in relation to genetic variations in the VDR polymorphisms<sup>14</sup>. In a population-based cohort of Swedish older women, low 25 (OH) D levels correlated with poor balance, low gait speed and low physical activity and increased risk of fracture<sup>15</sup>.

In our study, there was a positive correlation between serum 25 (OH) D level and muscle strength determined by the hand grip strength. Furthermore, the participants with lower serum levels of 25 (OH) D had poor balance. Consistent with the results of this study, a former study analyzing the relation between vitamin D status and muscle function in a group of healthy women aged over 65 years showed that serum 25 (OH) D levels  $\geq 20$  ng/ml are needed for a better muscle function and strength<sup>16</sup>. In that study, no difference in performance on the balance test were observed between groups which was concluded to be due to the age related degenerative changes in sensorial systems maintaining balance and posture rather than low serum 25 (OH) D level.

For this reason, in our study we excluded the participants that have degenerative and neurologic diseases that would affect balance to avoid the bias of the study mentioned above.

## CONCLUSIONS

In conclusion, in this small population of patients over 65 years of age, a large percentage of participants had nutritional vitamin D deficiency.

Hand grip strength as an easy measurement of muscle strength and Berg balance scale for assessment of balance could be routinely used in clinical practice to estimate the risk of falls in older population. The results of our study revealed that serum 25 (OH) D levels correlate with muscle strength and balance. Vitamin D deficiency must be treated to improve muscle strength and balance to reduce falls and fall-related complications in older population. Preventive measures for vitamin D insufficiency should also be considered especially in older population including routine prescription of vitamin D<sub>3</sub> supplements similar to the recommendations for other vulnerable populations such as exclusively breast-fed newborns and infants.

**Conflict of interest statement:** None declared.

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