



Ann Med Res

Current issue list available at AnnMedRes

Annals of Medical Research

journal page: www.annalsmedres.org

The correlation between vitamin D levels and inflammation, as well as the Prognostic Nutritional Index (PNI), in older adults

Nurgul Arslan^{a,*}, Bulent Yaprak^b^aDicle University, Ataturk Faculty of Health Sciences, Nutrition and Dietetic Department, Diyarbakır, Türkiye^bTurgut Ozal University, Malatya Training and Research Hospital, Department of Internal Medicine, Malatya, Türkiye

Abstract

Aim: Older adults' populations often have insufficient vitamin D (vit-D), which may contribute to autoimmune diseases and inflammation. Few studies have examined vit-D levels and immune function in humans. The study looked at vit-D levels and inflammatory markers in older adults.

Materials and Methods: Retrospective research was done. The hospital's records were searched for the study's data. Participants were 65-year-olds who applied to the geriatrics and internal medicine outpatient clinic between May 2020 and May 2022. Each person's vit-D nmol/L, CRP(mg/L), lymphocyte/monocyte, neutrophil/lymphocyte, platelet/lymphocyte, ferritin, and prognostic nutritional index (PNI) levels were measured.

Results: A total of 427 outpatients who applied to the geriatrics and internal medicine outpatient clinic between May 2020 and January 2022 were analyzed. Among these patients, 103 did not meet study criteria. A total of 324 participants who met the study criteria were evaluated and the participants' mean age was 73.21±5.24 years. The mean level of vit-D found in older adults was 14.18±6.14 nmol/L. It was discovered that there was a negative correlation that was statistically significant between the individuals' levels of vit-D and the ratio of CRP(mg/L) to MPV(fL) ($p<0.05$). Vit-D and PNI were found to have a correlation of $r=0.205$, which was found to be positive and significant ($p<0.05$). Logistic regression analysis was performed with vit-D level and related factors. Every 0.721 increase in PNI result in an additional unit of 25(OH) vit-D. It was found that the CRP (mg/L) variable contributed significantly to the model, and it was discovered that the presence of 1 unit of 25(OH) vit-D was increased for every 0.202 unit decrease ($p<0.05$).

Conclusion: Insufficient vitamin 25(OH)D is found in the older adults population. 25(OH) vit-D has a negative relationship with CRP and MPV, but a positive relationship with PNI, an indicator of nutritional status. The study suggests that vit-D supplements should be provided if an older adult has adequate vit-D.

ARTICLE INFO

Keywords:

25(OH) vit-D
Older adults
Inflammation
Nutrition

Received: Dec 30, 2022

Accepted: Jun 21, 2023

Available Online: 25.07.2023

DOI:

[10.5455/annalsmedres.2022.12.396](https://doi.org/10.5455/annalsmedres.2022.12.396)

Copyright © 2023 The author(s) - Available online at www.annalsmedres.org. This is an Open Access article distributed under the terms of Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

Introduction

Due to the high prevalence of vitamin D (vit-D) deficiency and insufficiency in populations, research on the epidemiology of vit-D status in various populations has revealed that these conditions are considered to be public health problems [1]. Vit-D normally, which is defined as a serum 25(OH)D level between 25 and 50 nmol/L, and vit-D deficiency, which is defined as a level below 25 nmol/L, are very prevalent in many countries around the world [2]. Numerous harmful health effects are linked to low serum vit-D concentrations. This is due to the fact that vit-D

has a wide range of functions in human physiology since calcium and phosphorus are involved in the homeostasis of vit-D, which is a fat-soluble vitamin, it is crucial for the health of bones [3]. There is some disagreement over the connection between 25-OH-D levels and inflammatory markers in healthy adult subjects. Not a single shred of evidence suggested a connection between 25-OH-D and either CRP or IL-6, which 1381 adults from the Framingham Offspring Study were used in this study; their mean age was 59 [4]. Clendenen et al. [5], confirmed these findings in a smaller sample of adult women with a mean age of 55 years. On the other hand, larger population-based studies conducted in Germany and the United States of America discovered a relationship between 25-OH-D and CRP that

*Corresponding author:

Email address: nuracar_1986@hotmail.com (Nurgul Arslan)

was shaped like a U [6, 7]. Data from the National Health and Nutrition Examination Survey (NHANES), which included 15167 adults with a mean age of 46, only for 25-OH-D levels that are below 21 ng/mL show an inverse relationship between 25-OH-D and CRP, and it was emphasized that there was a positive relationship above this threshold [6]. It's possible that different age groups and populations have different levels of vit-D sufficiency [8]. Because of their low prevalence of vit-D status and the associated health risks, older adults are considered to be a population group that is particularly susceptible to vulnerability. It is common knowledge that a lack of vit-D can lead to musculoskeletal complications, such as proximal myopathy and bone and muscle pain; diseases, such as secondary hyperparathyroidism, osteoporosis, and osteomalacia; and chronic diseases (cancer and cardiovascular diseases). Recent research [9-12] has shown that having insufficient concentration vit-D can lead to autoimmune diseases (such as systemic lupus erythematosus, multiple sclerosis, scleroderma or systemic sclerosis, and autoimmune thyroid diseases), rheumatoid arthritis, and psychotic disorders. In Turkey, research was carried out to investigate the epidemiology of vit-D status in a variety of populations. Turkey is a country that can be found between the meridians of 26° and 45° east and the parallels of 36° and 42° north, and it has a senior population of approximately 8 million people [12-14]. In spite of the fact that Turkey has a high irradiation time in mid-latitudes, a significant percentage of the population, particularly the older adults, suffers from vit-D deficiency. There have only been a handful of studies that have looked into the connection between vit-D levels and the decline in immune function that comes with aging in humans. The aim of study was to find out correlation between concentration vit-D that older adults have and inflammatory markers in their bodies.

Materials and Methods

Study design and ethics committee

A total of 427 outpatients who applied to the geriatrics and internal medicine outpatient clinic between May 2020 and January 2022 were analyzed. Among these patients, 103 did not meet study criteria. A total of 324 participants who met the study criteria were evaluated. Laboratory findings and demographic information tests of all participants included in the study were retrospectively scanned from patient files and hospital database and used in our study. The records kept by Malatya Turgut Özal University Education and Research Hospital were scanned. The regional ethics committee agreed that the study could proceed without compromising ethical standards and gave its blessing. The most recent version of the Declaration of Helsinki was adhered to throughout every stage of the research project. Ethics committee decision of the study was taken from Malatya Turgut Ozal University Non-Interventional Research Ethics Committee on 17.12.2022.

Inclusion criteria for the study

It was determined that the participants in the study were over the age of 65, did not suffer from any form of autoimmune disease, had previously collected hematological findings along with vit-D levels, and were not taking any form of vit-D supplementation.

Exclusion criteria

The presence of active infections (within the previous month), a history of recurrent kidney stones, overt kidney failure, the use of corticosteroids or other immunosuppressive drugs within the previous six months, and the use of vit-D within the previous six months were all taken into consideration.

Prognostic Nutritional Index (PNI)

The PNI was calculated using the formula; $[10 \times \text{serum albumin (g/dL)} + 0.005 \times \text{total lymphocyte count (mm}^3\text{)}]$.

For the PNI, a score of >56.1 was considered normal, scores of 50.0 to 56.1 were considered mild to moderate, and scores of <50.0 were considered severe malnutrition [15].

The determination of 25(OH) vitamin D levels through measurement and analysis

For the purpose of the study, a health care professional used venipuncture to extract five milliliters of blood from each participant while they had a full stomach. Within three hours of collecting the samples, they were centrifuged for fifteen minutes at a speed of three thousand revolutions per minute. Aliquots of serum were labeled and kept at a temperature of -80 degrees Celsius until they were required for analysis. Total serum 25(OH)D (D2 + D3) concentrations were measured utilizing a method that has been fully validated. In accordance with previously published cutoffs [16], vit-D deficiency, insufficiency, and sufficiency were defined as concentrations of less than 25, between 25 and 75, and more than 75 nmol/L, respectively, for the purposes of this study.

Biochemical findings

Blood samples taken from individuals were analyzed in the Biochemistry laboratory of Malatya Turgut Özal University, Training and Research Hospital, on the day the blood sample was taken.

Statistical analysis

The program known as SPSS (Statistical Package for the Social Sciences) was utilized in order to conduct analysis on the collected data. For quantitative variables, the descriptive statistics presented were the mean and standard deviation, and for qualitative variables, the number of cases as a percentage was presented. Before comparing the groups in terms of numerical variables, the hypotheses underlying parametric tests normality and homogeneity of variances were investigated and validated. The Shapiro Wilks test was carried out in order to determine whether or not the numerical variables exhibited normal distribution. The degree to which the numerical variables and the Spearman correlation coefficient are correlated with one another. In every statistical test, the level of significance that was considered acceptable was 0.05.

Table 1. Characteristics of individuals according to 25(OH)D levels.

	n=324	n=324	25(OH)D<25 nmol/l Insufficient n=145	25 nmol/l <25(OH)D<75 nmol/l Normal n=166	75 nmol/l<25(OH)D Excess n=13	p value
25(OH)D (nmol/l)	27.11±13.23		14.18±6.14	32.23±4.12	79.29±2.28	0.299
Age(years)(mean±SD)	73.21±5.24					
Gender						
Female	189(58.33)	24.11±8.19				
Male	135(41.67)	34.21±6.81				
Disease Status						
Osteoarthritis	15(4.63)					
Hypertension	26(8.02)					
Diabetes	56(17.28)					
Smoking Status						
Yes	67(20.68)					
No	257(79.32)					
BMI(kg/cm ²)(mean±SD)	23.11±4.24					
PNI Status(mean±SD)		58.21±11.23	44.21±12.13	52.11±8.13	59.23±14.15	0.133

mean±SD: mean ± Standard Deviation.

Table 2. Correlation coefficients (r) of 25(OH)D/nmol and PNI, hematological results of individuals.

Variables	25(OH)D nmol	PNI	CRP(mg/dl)	MPV (fL)	NLR	PLR	Homocysteine (µmol/L)	Ferritin (mg/dl)	Blood glucose(mg/dl)	Age (year)
25(OH)D nmol	1	0.205*	-0.075	-0.251*	0.109	-0.099	0.24	-0.099	0.045	-0.191*
PNI		1	-0.287*	0.099	0.107	0.186	0.056	0.207	0.071	0.142
CRP(mg/dl)			1	0.104	0.204*	0.306*	0.091	0.165	0.109	0.082
MPV (fL)				1	0.082		0.092	0.141	0.145	0.139
NLR					1	0.191	0.065	0.088	0.106	0.125
PLR						1	0.088	0.096	0.038	0.099
Homocysteine (µmol/L)							1	0.104	0.044	0.102
Ferritin (mg/dl)								1	0.074	0.064
Blood glucose(mg/dl)									1	0.67
Age (year)										1

MPV: Mean Platelet Volume, NLR: Neutrophil-Lymphocyte Ratio, PLR: Platelet-Lymphocyte Ratio, CRP: C-reactive protein. PNI: prognostic nutritional index. r=Spearman correlation coefficient. *p<0.05.

Table 3. Estimation of Vitamin D Status by logistic regression analysis.

	25(OH)D Vitamin Status		
	OR	%95 CI	p
PNI	0.721	(0.221-1.102)	0.002*
CRP (mg/L)	0.202	(0.175-0.566)	0.012*
MPV (fL)	0.345	(0.232-0.621)	0.129
NLR	0.088	(0.041-0.192)	0.781
PLR	0.104	(0.065-0.204)	0.198
Homocysteine (µmol/L)	0.014	(0.010-0.378)	0.931
Ferritin(mg/L)	0.081	(0.028-0.109)	0.389

MPV: Mean Platelet Volume-mean platelet volume, NLR: Neutrophil-Lymphocyte Ratio, PLR: Platelet-Lymphocyte Ratio, CRP: C-reactive protein. PNI: prognostic nutritional index. r=Spearman correlation coefficient. *p<0.05. OR:Odds Ratio, CI: confidence interval.

Results

The distribution of individuals according to the concentration 25(OH) vit-D that they have as well as their gen-

eral characteristics presented in Table 1. It was discovered that 44.75% of the population had insufficient levels of 25(OH)D, while 51.23% had adequate levels. The mean age of the group was 73.21±5.24 years. When the concentration 25(OH) vit-D were analyzed according to gender, it was discovered that the concentration 25(OH) vit-D in women were 24.11±8.19 nmol/l, while the levels of 25(OH) vit-D in men were 34.21±6.81 nmol/l (p<0.05). It was determined that the mean body mass index was 23.11 ±4.24 kg/cm², that 17.28% of the population had diabetes, and that 20.68% of the population smoked cigarettes. Correlation coefficients of 25(OH)D/nmol and PNI, hematological results of individuals showed in Table 2. The level of 25(OH)D was found to have a correlation with the level of PNI that was found to be positive and significant (r = 0.205, p = 0.001). On the other hand, a negative and statistically significant correlation was found to exist between 25(OH)D and MPV(fL) (r = -0.251, p = 0.023). It was discovered that logistic regression of the model was important for predicting the 25(OH)D vit-D status in individuals (Table 3). PNI, CRP (mg/L), MPV (fL), NLR, PLR, Homocysteine (mol/L), and Ferritin were included

in the model that was developed. One unit of 25(OH)D vitamin is produced for every 0.721 unit increase in PNI. It was discovered that the variable CRP (mg/L) contributed significantly to the model, and that each decrease of 0.202 units increased the presence of 1 unit of 25(OH)D vitamin ($p < 0.05$).

Discussion

This study was conducted retrospectively. In total, there were 324 older adults involved in the research. There was a connection between the levels of PNI and MPV (fL) in individuals and the vit-D concentration. The Prognostic Nutritional Index (PNI), which is an indicator of nutritional status, was found to have a positive correlation with vit-D. On the other hand, an inverse correlation was found between the inflammatory marker MPV (fL) and vit-D levels. MPV (fL) is an indicator of inflammation. In the correlation analysis conducted in the study, a positive and significant relationship was found between vitamin D and nutritional index ($r = 0.205$, $p = 0.001$). A negative correlation was observed between vitamin D and MPV, which is an inflammation marker ($r = -0.251$, $p = 0.023$). Reducing inflammation is a mechanism that can enhance either direct catabolic effects or indirect mechanisms in older adults, as it can in all other populations (higher GH and IGF-I concentrations, less anorexia, etc.). It has been observed that taking vit-D supplements results in a lower level of CRP, which is particularly beneficial to catabolism. It is believed that individuals with low levels of vit-D will have an increased rate of catabolism [17]. Within the scope of this investigation, it was determined that the individuals' vit-D concentrations, on average, were within the healthy range. Besides, it was found that the typical amount of vit-D that female individuals possessed was below adequate levels. In a number of studies, it was discovered that older adults have an inadequate nutritional status [18, 19]. It was discovered that 61.22% of individuals with malnutrition had low concentrations of vitamin when the nutritional status of an older adults group was screened by MNA [20]. Discovery was made in a group of people whose nutritional status was determined by MNA. It was emphasized in another study that the risk of co-occurrence of inflammation and malnutrition is higher in individuals [21] and this finding was supported by the findings of the previous study. In light of the results of a study carried out by Santabalbina et al. [11] discovered that the CRP concentration older adults who had low levels of vit-D were significantly higher than those who had normal levels of vit-D. It was emphasized in a study that used a large sample size that the appetite, which is the desire for food intake, of older adults individuals with low vit-D levels is at lower levels, and this situation causes many infectious diseases [22]. The study used a large sample size because it wanted to make sure that the findings were accurate. There is a possibility that an inadequate immune and inflammatory response is at the root of all chronic diseases, including cancer, that are more common in populations of older adults. A high risk profile is defined for cognitive symptoms, depression, poor physical performance, and mortality when inflammation is present. Because inflammation affects survival, this is the

case. The importance of nutrition in these processes cannot be overstated. Anorexia of aging is primarily caused by chronic low-grade inflammation, whereas acute inflammation may increase energy needs and, as a result, cause the emergence of "disease-associated malnutrition" [23].

In the limited number of population-based studies that have been conducted specifically in older adults cohorts, a new angle on the relationship between vit-D and inflammation has emerged. Subjects with anemia had a higher rate of chronic inflammation, and anaemic subjects who did not have a significantly higher prevalence of vit-D deficiency (56% vs 33%, $p = 0.008$) [24]. This was found in a large study of community-dwelling Americans aged 60 years. Those with 25-OH-D levels below 24 ng/mL had a significantly increased risk of anemia (OR 1.46, 95% CI 1.06–2.02). Vit-D supplementation did not have any additional effect on systemic inflammation, as measured by changes in serum CRP levels, in asymptomatic subjects who had baseline vit-D values of less than 21 ng/ml, according to the findings of another study. Another study highlighted that the difference in CRP levels between individuals with low and high concentration vit-D was probably due to the anti-inflammatory property of vit-D [6], and this was attributed to the fact that vit-D was present in both groups. According to the findings of this investigation, there is an inverse relationship, which is statistically significant, between the amount of vit-D and MPV (fL). Another result that was significant was found to exist between the levels of vit-D and the PNI values. It has been found that people who have a healthy nutritional status have high degree vit-D in their bodies.

25-hydroxy vit-D, also known as 25-OH-D, is found in lower concentrations in older adults as they age. The prevalence of vit-D insufficiency or deficiency was found to be extremely high across all age groups and geographic regions, according to a review that was conducted using a systematic approach. On the other hand, the prevalence of the disease in older adults people is even higher than it is in other groups and approaches 90% [17]. The causes of insufficient vit-D status in older adults have not been fully demonstrated and most remain speculative. This is because the causes have not been adequately investigated. It should be emphasized that there are factors such as insufficient time spent outdoors in the sun, insufficient food intake, chronic diseases, relative increase in fat mass and changes in body composition, physical and cognitive disability, and polypharmacy. These factors all play a role. It is extremely unlikely that an older adult person will develop vit-D deficiency as a result of insufficient vit-D intake. On the other hand, only one percent of participants in a recent cross-sectional study of 794 Australian men aged 75 years and older met the recommended Nutritional Reference Value (NRV) for vit-D intake in their age group [25]. The study was conducted in Australia. The factors that are associated with an individual's average vit-D level were investigated throughout the course of this study. It was observed that there is a connection between the PNI value, which is an indicator of nutritional status, and vit-D. It has been found that people who have low levels of vit-D are also in a poor state when it comes to their nutrition. It has been discovered that there is a

connection between the intake of vit-D and CRP, which is a measurement that can be used to gauge the level of inflammation. Having a low PNI, which is an indicator of nutritional status, was found to be associated with having high CRP levels; however, it was also discovered that these individuals had insufficient vit-D levels.

Conclusion

Older adults have been identified as a group in which the long-term effects of vit-D deficiency may be worsened. It has been pointed out that there may be a connection between vit-D and the outcomes of hematological tests and malnutrition. According to the findings of this research, there is a connection between vit-D and the biomarkers of the body's inflammatory response. It is recommended, especially for older adults, to take vit-D supplements and get their 25(OH)D levels checked.

Ethical approval

Ethics committee approval of the study was received from Malatya Turgut Özal University Non-Invasive Research Ethics Committee on 17.12.2022.

References

- van Schoor N, Lips P. Worldwide vitamin D status. *Vitamin D*. 2018;15-40.
- Buta B, Choudhury PP, Xue QL, Chaves P, Bandeen-Roche K, Shardell M, et al. The association of vitamin D deficiency and incident frailty in older women: the role of cardiometabolic diseases. *Journal of the American Geriatrics Society*. 2017;65(3):619-24.
- Watson J, Lee M, Garcia-Casal MN. Consequences of inadequate intakes of vitamin A, vitamin B12, vitamin D, calcium, iron, and folate in older persons. *Current geriatrics reports*. 2018;7(2):103-13.
- Shea MK, Booth SL, Massaro JM, Jacques PF, D'Agostino Sr RB, Dawson-Hughes B, et al. Vitamin K and vitamin D status: associations with inflammatory markers in the Framingham Offspring Study. *American journal of epidemiology*. 2008;167(3):313-20.
- Clendenen TV, Koenig KL, Arslan AA, Lukanova A, Berrino F, Gu Y, et al. Factors associated with inflammation markers, a cross-sectional analysis. *Cytokine*. 2011;56(3):769-78.
- Amer M, Qayyum R. Relation between serum 25-hydroxyvitamin D and C-reactive protein in asymptomatic adults (from the continuous National Health and Nutrition Examination Survey 2001 to 2006). *The American journal of cardiology*. 2012;109(2):226-30.
- Mellenthin L, Wallaschofski H, Grotevendt A, Völzke H, Nauck M, Hannemann A. Association between serum vitamin D concentrations and inflammatory markers in the general adult population. *Metabolism*. 2014;63(8):1056-62.
- Moo IH, Kam CJW, Cher EWL, Peh BCJ, Lo CE, Chua DTC, et al. The effect of the comorbidity burden on vitamin D levels in geriatric hip fracture. *BMC Musculoskeletal Disorders*. 2020;21(1):1-8.
- Akbar MR, Wibowo A, Pranata R, Setiabudiawan B. Low serum 25-hydroxyvitamin D (vitamin D) level is associated with susceptibility to COVID-19, severity, and mortality: a systematic review and meta-analysis. *Frontiers in Nutrition*. 2021;8:131.
- Jenkins DJ, Spence JD, Giovannucci EL, Kim Y-i, Josse RG, Vieth R, et al. Supplemental vitamins and minerals for cardiovascular disease prevention and treatment: JACC focus seminar. *Journal of the American College of Cardiology*. 2021;77(4):423-36.
- Tarazona-Santabalbina FJ, Cuadra L, Cancio JM, Carbonell FR, Garrote JMP-C, Casas-Herrero Á, et al. VitaminD supplementation for the prevention and treatment of COVID-19: a position statement from the Spanish Society of Geriatrics and Gerontology. *Revista Española de Geriatria y Gerontología*. 2021;56(3):177-82.
- Pilling LC, Jones LC, Masoli JA, Delgado J, Atkins JL, Bowden J, et al. Low vitamin D levels and risk of incident delirium in 351,000 older UK Biobank participants. *Journal of the American Geriatrics Society*. 2021;69(2):365-72.
- Lieberman K, Njemini R, Luiking Y, Forti LN, Verlaan S, Bauer JM, et al. Thirteen weeks of supplementation of vitamin D and leucine-enriched whey protein nutritional supplement attenuates chronic low-grade inflammation in sarcopenic older adults: the PROVIDE study. *Aging clinical and experimental research*. 2019;31(6):845-54.
- Silva B, Camões M, Simões M, Bezerra P. Obesity, physical fitness and inflammation in the elderly. *Geriatrics*. 2017;2(4):30.
- Yan D, Shen Z, Zhang S, Hu L, Sun Q, Xu K, et al. Prognostic values of geriatric nutritional risk index (GNRI) and prognostic nutritional index (PNI) in elderly patients with Diffuse Large B-Cell Lymphoma. *Journal of Cancer*. 2021;12(23):7010.
- Meftahi GH, Jangravi Z, Sahraei H, Bahari Z. The possible pathophysiology mechanism of cytokine storm in elderly adults with COVID-19 infection: the contribution of "inflammation-aging". *Inflammation Research*. 2020;69(9):825-39.
- Hilger J, Friedel A, Herr R, Rausch T, Roos F, Wahl DA, et al. A systematic review of vitamin D status in populations worldwide. *British journal of nutrition*. 2014;111(1):23-45.
- Fernández-Barrés S, Martín N, Canela T, García-Barco M, Badora J, Arijia V, et al. Dietary intake in the dependent elderly: evaluation of the risk of nutritional deficit. *Journal of Human Nutrition and Dietetics*. 2016;29(2):174-84.
- Bauer JM, Kaiser MJ, Anthony P, Guigoz Y, Sieber CC. The mini nutritional assessment®—its history, today's practice, and future perspectives. *Nutrition in clinical practice*. 2008;23(4):388-96.
- Christner S, Ritt M, Volkert D, Wirth R, Sieber C, Gafmann KG. Evaluation of the nutritional status of older hospitalised geriatric patients: a comparative analysis of a Mini Nutritional Assessment (MNA) version and the Nutritional Risk Screening (NRS 2002). *Journal of Human Nutrition and Dietetics*. 2016;29(6):704-13.
- Juneja M, Baidoo L, Schwartz MB, Barrie A, Regueiro M, Dunn M, et al. Geriatric inflammatory bowel disease: phenotypic presentation, treatment patterns, nutritional status, outcomes, and comorbidity. *Digestive diseases and sciences*. 2012;57(9):2408-15.
- Kositsawat J, Barry LC, Kuchel GA. C-reactive protein, vitamin D deficiency, and slow gait speed. *Journal of the American Geriatrics Society*. 2013;61(9):1574-9.
- Brown PJ, Roose SP, Zhang J, Wall M, Rutherford BR, Ayonayon HN, et al. Inflammation, depression, and slow gait: a high mortality phenotype in later life. *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences*. 2016;71(2):221-7.
- Perlstein TS, Pande R, Berliner N, Vanasse GJ. Prevalence of 25-hydroxyvitamin D deficiency in subgroups of elderly persons with anemia: association with anemia of inflammation. *Blood, The Journal of the American Society of Hematology*. 2011;117(10):2800-6.
- Waern RV, Cumming RG, Blyth F, Naganathan V, Allman-Farinelli M, Le Couteur D, et al. Adequacy of nutritional intake among older men living in Sydney, Australia: findings from the Concord Health and Ageing in Men Project (CHAMP). *British Journal of Nutrition*. 2015;114(5):812-21.