Vitamin D level among patients referred by general practitioners to the Geriatric Ward

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A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

INTRODUCTION

The main source of vitamin D (~95%) is UVB (Ultraviolet B) radiation from sunlight. The amount contained in the diet is insufficient and significantly below the daily requirement. Latitude is a determining factor for the extent of UVB radiation from sunlight. The amount contained in the diet is insufficient and significantly below the daily requirement. Despite common knowledge of the pleiotropic role in maintaining health, supplementation of vitamin D is not required to begin vitamin D supplementation in the elderly. The aim of the study was to analyze the vitamin D level among patients at least 60 years old referred by primary general practitioners to the Geriatric Department of the District Hospital in Jasło, southeastern Poland, depending on age, referral mode and presence of frailty syndrome.

MATERIALS AND METHOD

The study included 601 patients aged 60 years and over, hospitalized during the period 1 October 2016 – 31 December 2017 at the Geriatric Department of the District Hospital in Jasło. All of them were referred to the Geriatric Ward, Specialized Hospital, Jasło, Poland, vitamin D supplementation in the dose of 800–2,000 IU/day should be implemented all year round in the case of people aged 65–75, taking into account their body weight and supply of vitamin D in diet. Similar recommendations for a supplementation of 2,000–4,000 IU/day, apply to all people over 75 years of age. The risk of overdosing with vitamin D is very rare. The concentration of 250 nmol/l is completely safe [5,7,8].

OBJECTIVE

The aim of the study was to analyze the vitamin D level among patients aged 60-years-old or over, referred to the Geriatric Department of the District Hospital in Jasło, southeastern Poland, by primary care physicians, depending on age, referral mode and presence of frailty syndrome.

RESULTS

The proper level of 25OH-vitamin D (>75 nmol/l) was found in 17.35 % (N=104) of patients, the least frequent in the oldest (15.0%, N=41 of 80-year-olds; 7.1%, N=5 of 90-year-olds; p=0.000). The low level of 25OH-vitamin D (< 50 nmol/l) was present in 59.7% (N= 359), including significantly low (<25 nmol/l) in 27.6% (N=166) of patients. Significant deficiency was more frequent among the oldest (61.4%, N=43 of 90-year-olds), with frailty syndrome (43.9%, N=132; p=0.000) and referred urgently (49.7%, N=96; p=0.000). Before hospitalization, vitamin D had been used by 15.5% (N=53) of patients, more often women than men (18.8%, N=81 v. 7.0%, N=12; p=0.000) and referred on schedule than urgently (18.1%, N=73 v. 9.8 %, N=19; p=0.000). No differences were fund by age and frailty syndrome.

Conclusions. Despite common knowledge of the pleiotropic role in maintaining health, supplementation of vitamin D is still an unsolved problem among the elderly.

METHODS

The study included 601 patients aged 60 years and over, hospitalized during the period 1 October 2016 – 31 December 2017 at the Geriatric Department of the District Hospital in Jasło. The serum concentration of 25OH-D was tested on the first day of their hospitalization.

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referred to the acute geriatric ward by their family doctors as
distributed (67.2%, N=404) and urgent (32.1%, N=193) admissions. The serum concentration of 25OH-D was tested
on the first day of hospitalization. The following diagnostic
criteria were adopted: 75–124 nmol/l = recommended level of
25OH-D, 50–74 nmol/l = suboptimal level (hypovitaminosis)
of 25OH-D, 25–49 nmol/l = deficiency of 25OH-D and 0–24
nmol/l = significant deficiency of 25OH-D.

**Statistical analysis.** Statistical analysis was performed with
the use of STATISTICA 13. χ² Pearson test was used in order
to investigate a relationship between the two qualitative
variables. In cases where the value of the test could be
highly imprecise, i.e. when the total number of observations
was small or expected values were found to be very low,
the Fisher test was conducted. In order to investigate the
differences between percentages, a test for proportions was
performed.

The occurrence of statistically significant differences
between the two means in individual populations was
investigated with the use of Student’s t-test (when respective
tests did not show homogeneity of variance, an
alternative test, which is Cochran-Cox test, was conducted),
or in the case of not fulfilling the assumptions of normality
distributions, the U Mann-Whitney test was performed,
which is its non-parametric equivalent. An occurrence of
statistically significant differences between more than two
means in individual populations was investigated with the
use of ANOVA Kruskal Wallis test, and in the case of its
positive result, in order to identify which means differ from
each other significantly, the test of multiple comparisons
using rank sums was conducted.

For auxiliary purposes (in order to check assumptions
of the above-mentioned tests), the Shapiro-Wilk test was
used (assessment of normality of distribution) as well as the
F-test and Levene’s test (assessment of homogeneousness
of variance). The level of significance was set at p<0.05.

**RESULTS**

In the analyzed group of 601 patients, the proper serum
25OH-D level, i.e. at least 75 nmol/l, was found only in 17.3 %
(N=104) of patients. In 59.7% (N=359) of patients, the level
of 25OH-D was lower than 50 nmol/l, including in the case of
27.6% (N=166) the deficiency was very significant, since
the concentration was lower than 25 nmol/l. The remaining
23.0% (N=138) of patients had suboptimal levels, i.e. hypovitaminosis of 50–74 nmol/l (Fig. 1).

A relevant 25OH-D deficit – a concentration of 0–24 – was
significantly more frequent among the oldest patients, i.e. at
least 90 years of age (61.4%, N=43). Recommended values, i.e.
with at least 75 nmol/l, were the least frequent in this oldest group
of patients (7.1%, N=5), and also rare in the group of 80-year-
olds (15.0%, N=41). Generally, in increasingly older groups of
patients (10-year age intervals), the percentage of those who
had serum concentrations of 25OH-D at a recommended
level were decreasing (p=0.000). Statistically significant
differences between individual intervals of patients were
confirmed in the test for multiple comparisons using rank
sums (Fig. 2).

There were no statistical differences in the concentrations
of 25OH-D between men and women (18.8 %, N=81 v. 13.5%,
N=23). It has been shown that a significant deficiency of
25OH-D was more frequent in the case of urgent than
scheduled admissions to hospital (49.7%, N=96 v. 17.3%,
N=70; p=0.000) and in patients with frailty syndrome,
compared to those classified as pre-frail and robust (43.9%,
N=132 v. 14.4%, N=22 v. 8.2%, N=12; p=0.000). In the frailty
group, the recommended values were the least frequent in
comparison with the pre-frail and robust patients (10.6%,
N=32 v. 22.9%, N=35 v. 25.2%, N=37; p=0.000). Additionally,
statistically significant differences in the level of 25OH-D
between patients with frailty syndrome and those who were
classified as pre-frail and robust were confirmed in the test
for multiple comparisons using rank sums (Fig. 3, 4).

In the analyzed group of 601 patients, only 15.5% (N=93)
had supplemented vitamin D before hospitalization. More
than half of them (50.5%, N=47) had the recommended
serum concentration of 25OH-D of over 75 nmol/l. In every
fifth patient had been taking vitamin D (21.5%, N=20) there

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**Figure 1.** Level of 25OH-D among patients referred to the acute geriatric ward by general practitioners

**Figure 2.** Level of 25OH-D among patients referred to the geriatric ward by general practitioners, depending on age (p=0.000)

**Figure 3.** Level of 25OH-D among patients referred to the geriatric ward by general practitioners, depending on referral mode (p=0.000)
was a level of 25OH-D under 50 nmol/l. In the group who did not supplement vitamin D, only 10.6% (N=57) had a 25OH-D level over 75 nmol/l, and as much as 66.7% (N=339) had a 25OH-D level below 50 nmol/l (p=0.000). Among patients with a significant deficiency of 25OH-D (below 25 nmol/l), deficiency (25–49 nmol/l) and hypovitaminosis (50–74 nmol/l), patients who did not supplement vitamin D dominated (97.6%, N=162 v. 91.7%, N=177 v. 81.2%, N=112; p = 0.000) (Tab. 1).

Vitamin D was taken significantly more often by women than men (18.8%, N=81 v. 7.0%, N=12; p = 0.000), and by patients referred to the geriatric ward in a scheduled, non-urgent way (18.1%, N=73 v. 9.8%, N=19; p = 0.000). Among patients who were taking vitamin D supplementation, there were no statistically significant differences depending on age and the occurrence of frailty syndrome (Tab. 1).

**Table 1.** Relationship between participants’ characteristics and vitamin D supplementation

| Parameter                      | No. of patients | Vitamin D supplementation before hospitalization |
|--------------------------------|-----------------|-------------------------------------------------|
|                                |                 | YES | NO          | p     |
|                                |                 | num- | per- | num- | per- |
| 25OH-D concentration           | 601             | 93  | 15.5% | 508  | 84.5% |
| significant deficiency         | 166             | 4   | 2.4%  | 162  | 97.6% |
| deficiency                     | 193             | 16  | 8.3%  | 177  | 91.7% |
| suboptimal level               | 138             | 26  | 18.8% | 112  | 81.2% |
| recommended level              | 104             | 47  | 45.2% | 57   | 54.8% |
| 60-69 years                    | 64              | 10  | 15.6% | 54   | 84.4% |
| 70-79 years                    | 193             | 25  | 13.0% | 168  | 87.0% |
| 80-89 years                    | 274             | 53  | 19.3% | 221  | 80.7% |
| 90 and over years              | 70              | 5   | 7.1%  | 65   | 92.9% |
| gender                         |                 |     |       |      |      |
| female                         | 430             | 81  | 18.8% | 349  | 81.2% |
| male                           | 171             | 12  | 7.0%  | 159  | 93.0% |
| frailty syndrome               |                 |     |       |      |      |
| frailty                        | 301             | 42  | 14.0% | 259  | 86.0% |
| pre-frailty                    | 153             | 20  | 13.1% | 133  | 86.9% |
| robust                         | 147             | 31  | 21.1% | 116  | 78.9% |
| model of referral              |                 |     |       |      |      |
| urgent                         | 193             | 19  | 9.8%  | 174  | 90.2% |
| scheduled                      | 404             | 73  | 18.1% | 331  | 81.9% |

DISCUSSION

Testing the 25OH-D level is not within the competence of primary care physicians in Poland. However, it is not necessary to order vitamin D (cholecalciferol) supplementation neither is it required as a control of therapy effectiveness [5,3]. Of course, in the case of the elderly, where a 25OH-D deficiency below 50 nmol/l and even below 25 nmol/l can be expected, the possibility of performing such a test would allow for the use of higher, therapeutic doses [8]. This is important, because the biologically active 1,25OH-D, in addition to maintaining calcium and phosphorus homeostasis in the extracellular space, affects not only the skeletal system (increasing bone turnover, calcium deposition in the newly formed bone), but also probably the cardiovascular system (heart muscle remodeling, increased peripheral blood flow), the nervous system (differentiation, growth and transmission of signals between neurons, neuroplasticity of the brain), the muscular system (proliferation and differentiation of muscle fibers), and the immune system (e.g. inhibition of the proliferation of certain cells cancer and IL-6 production) [3, 5, 9].

In the analyzed group of 601 patients over 60 years of age (requirement of admission to the geriatric department imposed by the Polish National Health Fund), the correct level, i.e. a concentration of at least 75 nmol/ml of 25OH-D, was found only in 17.3% (N=104). In 59.7% (N=359), the 25OH-D level was lower than 50 nmol/l, thus requiring the use of therapeutic doses of vitamin D, whereas in 27.6% of patients (N=166) the 25OH-D level was lower than 25 nmol/l. A study conducted by Suryanarayana P et al. among 98 urban elderly (≥60 years) from Hyderabad, South India showed similar results. Vitamin D deficiency (<50 nmol/l) was present among 56.3% of the participants of the study [10]. A study by Hirani V et al., however, carried out on a group of 1,659 non-institutionalized men aged ≥70 years in Sydney, Australia, revealed that the prevalence of vitamin D insufficiency (<50 nmol/l) among them equaled 43.0% [11].

In the current study, a significant deficiency of vitamin D (25OH-D level below 25 nmol/l) occurred in 61.4% (N=43) of 90-year-olds, 43.9% (N=96) of with frailty syndrome and 49.7% (N=96) admitted urgently.

Vitamin D was supplemented by 15.5% (N=93) of patients, more often than women than men (18.8%, N=81 v. 7.0%, N=12; p = 0.000) and those admitted on schedule and non-urgently (18.1%, N=73 v. 9.8%, N=19; p = 0.000). It is of importance that patients with frailty syndrome admitted urgently and from the oldest age groups, and therefore with a much worse prognosis, did not supplementation more often than other groups. A study by Breysse C. et al. conducted among 163 French primary care patients over 65 years of age showed different results – 44% were taking vitamin D supplements [12]. A study by Orces CH and López Gavilánez E. among 5204 participants at the age of 60 or over in Spain showed that 45.3% of them reported taking vitamin D supplements, at least 400 IU per day, and female gender having > 2 comorbidities associated with increased odds of taking vitamin D supplements [13]. In half of the patients, the vitamin D level was adequate, which is at least 75 nmol/l (50.5%, N=47). In every fifth patient using vitamin D before hospitalization (21.5%, N=20), the concentration of 25OH-D was lower than 50 nmol/l. In the case of 4.3% (N=4) of patients, the level of 25OH-D did not exceed the concentration of 20 ng/ml. Among patients who were not supplementing with vitamin D, the level of at least 75 nmol...
In Poland, elderly people aged 65–75 years should monitor vitamin D at a dose of 800–2,000 IU/d all year round, whereas those over 75 years of age in a dose of 2,000–4,000 IU/d, depending on body weight, vitamin D supply in the diet and sun exposure [5]. In obese people with BMI >30 kg/m², the recommended dose is 1,600–4,000 IU/d, depending on the severity of obesity [27]. The recommended therapeutic doses of vitamin D for adults—and the elderly—are 7,000–10,000 IU/d or 50,000 IU/weekly for a period of at least 1–3 months (the control 25OH-D level should be performed not earlier than after 8–12 weeks from the start of treatment). Patients with a severe liver dysfunction or chronic renal disease are the only groups that require the use of activated vitamin D metabolites [calcifediol v. alfacalcidol or 1,25-dihydroxyvitamin D3 (calcitriol)] [8].

Vitamin D toxicity is extremely rare. In very rare cases of granulomatous diseases, e.g. sarcoidosis, some lymphomas and primary hyperparathyroidism, vitamin D should be supplemented with caution, taking into account the risk of hypercalcaemia [27]. However, it should be borne in mind that high intermittent doses of vitamin D may increase the risk of falls and fractures, and that long-term use of vitamin D in connection with significant doses of calcium (1,000–1,500 mg / d) increases the risk of kidney stones in patients with a high calcium intake [2].

Serum concentration of 25OH-D up to 250 nmol/l is completely safe. Symptoms of poisoning may appear only at concentrations exceeding 375 nmol/l (VDT: vitamin D intoxication). At concentrations above 250 nmol/l, vitamin D supplementation should be discontinued, calcemia and calcuria assessed, and the concentration of 25OH-D monitored at monthly intervals until the level of 125 nmol/l is reached [3, 5, 7, 28].

**CONCLUSIONS**

1. The problem of vitamin D deficiency among seniors is very widespread, since a correct level of 25OH-D was found only in 17.3% of patients over 60-years-old from the investigated group.
2. Groups particularly affected by a significant deficiency of 25OH-D were individuals over 90 years of age, and those with frailty syndrome.
3. The study shows that vitamin D supplementation among the investigated group of Polish seniors is low. Only a small percentage (15.5%) had supplemented vitamin D before hospitalization. The consequences of this phenomenon are significant, since only a half of seniors from the supplementing group had a proper 25OH-D serum level, whereas among patients who did not supplement vitamin D before hospitalization, this percentage equalled 11.2%.
4. The results indicate that vitamin D deficiency among seniors is a significant issue in Poland. Due to serious consequences of this problem, family physicians should educate patients and ought to have the possibility to assess the level of this vitamin in primary care conditions.

**REFERENCES**

1. Cesari M, Incalzi RA, Zamboni V, et al. The vitamin D hormone: a multitude of actions potentially influencing the physical function decline in older persons. Geriatr Gerontol Int. 2011;11(2):133–42. https://doi.org/10.1111/j.1447-0594.2010.00668.x
2. Giustina A, Adler RA, Binkley N, et al. Consensus statement from 2nd International Conference on Controversies in Vitamin D. Rev Endocr Metab Disord. 2020;21(1):89–116. https://doi.org/10.1007/s11154-019-09532-w
3. Kirst AH, Davidson KW, Mangione CM, et al. Screening for Vitamin D Deficiency in Adults: US Preventive Services Task Force Recommendation Statement. JAMA 2021;325(14):1436–42. doi:10.1001/jama.2021.3069
4. Meehan M, Penkofer S. The role of vitamin D in the aging adults. J Aging Gerontol. 2014;2(2):60–71. https://doi.org/10.12974/2309-6128.2014.02.02.1
5. Rusinańska A, Płudowski P, Walczak M, et al. Vitamin D Supplementation Guidelines for General Population and Groups at Risk of Vitamin D Deficiency in Poland—Recommendations of the Polish Society of Pediatric Endocrinology and Diabetes and the Expert Panel With Participation of National Consultants and Representatives of Scientific Societies—2018 Update. Front Endocrinol (Lausanne). 2018;9:246. https://doi.org/10.3389/fendo.2018.00246

6. Lips P, Cashman KD, Lamberg-Allardt CL, et al. Current vitamin D status in European and Middle East countries and strategies to prevent vitamin D deficiency: a position statement of the European Calcified Tissue Society. Eur Soc Endocrinol. 2019;180(4):P23-P54. https://doi.org/10.1530/EJE-18-0736

7. Marciniowska-Sowierska E, Kupisz-Urbańska M, Łukaszkiewicz J, et al. Vitamin D Toxicity-A Clinical Perspective. Front Endocrinol (Lausanne). 2018;9:555. https://doi.org/10.3389/fendo.2018.00550

8. Płudowski P, Holick MF, Grant WB, et al. Vitamin D supplementation guidelines. J Steroid Biochem Mol Biol. 2018;175:125–35. https://doi.org/10.1016/j.jsbmb.2017.01.021

9. Remelli F, Vitali A, Zúñiga Rojo, E, et al. Vitamin D Deficiency and Sarcopenia in Older Persons. Nutrients. 2019;11(12):2861. https://doi.org/10.3390/nu11122861

10. Suryanarayana P, Arlappa N, Sai Santhosh V, et al. Prevalence of vitamin D deficiency and its associated factors among the urban elderly population in Hyderabad metropolitan city, South India. Ann Hum Biol. 2018;45(2):133–139. https://doi.org/10.1080/03014460.2018.1425479

11. Hirani V, Cumming RG, Blyth FM, et al. Vitamin D status among older community dwelling men living in a sunny country and associations with lifestyle factors: the Concord Health and Ageing in Men Project, Sydney, Australia. J Nutr Health Aging. 2013;17(7):587–593. https://doi.org/10.1007/s12603-013-0013-z

12. Brycese C, Guillot P, Berrut G. Etude de la supplémentation en vitamine D chez les personnes de plus de 65 ans en médecine générale [Study of vitamin D supplementation in people over 65 years in primary care]. Jpn J Geriatr Psychiatry. 2015;13(2):123–132. https://doi.org/10.1080/1684/pnv.2015.0530

13. Orces CH, López Gavilánnez E. Determinants of vitamin D supplementation among older adults and its effect on 25(OH)D levels according to bone mineral density status. Determinantes de la suplementación con vitamina D entre los adultos mayores y su efecto en los niveles de 25(OH)D según la densidad ósea. Nutr Hosp. 2020;37(1):28–36. https://doi.org/10.20960/nh.02917

14. Mossakowska M, Więcek A, Błędowski P, Pośniewski. Aspects medical, psychological, sociological and economic starzenia sie ludzi w Polsce. 1st ed. Termedia Wydawnictwo Medyczne, 2012

15. Aspell N, Laird E, Healy M, et al. Vitamin D Deficiency Is Associated With Impaired Muscle Strength And Physical Performance In Community-Dwelling Older Adults: Findings From The English Longitudinal Study Of Ageing. Clin Interv Aging. 2019;14:1751–61. https://doi.org/10.2147/CIA.S22143

16. Pennisi M, Malaguarnera G, Di Bartolo G, et al. Decrease in Serum Vitamin D Level of Older Patients with Fatigue. Nutrients. 2019;11(10):2531. https://doi.org/10.3390/nu11102531

17. Brenner H, Holleczek B, Schöttker B. Vitamin D Insufficiency and Deficiency and mortality from Respiratory Diseases in Cohort of Older Adults: Potential for Limiting the Death Toll during and Beyond the COVID-19 Pandemic? Nutrients. 2020;12(8):2488. https://doi.org/10.3390/nu12082488

18. Knutsen KV, Brekke M, Gjelstad S, et al. Vitamin D status in patients with musculoskeletal pain, fatigue and headache: A cross-sectional descriptive study in a multi-ethnic general practice in Norway. Scand J Prim Health. 2010;28:166–171. https://doi.org/10.1016/j.sjph.2013.03.024

19. Antoniak AE, Greig CA. The effect of combined resistance exercise training and vitamin D3 supplementation on musculoskeletal health and function in older adults: a systematic review and meta-analysis. BMJ Open. 2017;7(7):e014619. https://doi.org/10.1136/bmjopen-2016-014619

20. De Koning EL, Lips P. Penninx BWJH, et al. Vitamin D supplementation for the prevention of depression and poor physical function in older persons: the D-Vitaal study, a randomized clinical trial. Am J Clin Nutr. 2019;100(5):1119–30. https://doi.org/10.1093/ajcn/nqz141

21. Manson JE, Cook NR, Lee I-M, et al. Vitamin D Supplements and Prevention of Cancer and Cardiovascular Disease. N Engl J Med. 2019;380(1):33–44. https://doi.org/10.1056/NEJMoa1809944

22. Zhang Y, Fang F, Tang J, et al. Association between vitamin D supplementation and mortality: systematic review and meta-analysis. BMJ. 2019;366:14673. https://doi.org/10.1136/bmj.l4673

23. Hassan-Smith ZK, Hewison M, Gittos NJ. Effect of vitamin D deficiency in development countries. British Medical Bulletin. 2017;122(1):79–89. https://doi.org/10.1093/bmb/ldx005

24. Avenell A, Mak JCS, O’Connell D et al. Vitamin D and vitamin D analogues for preventing fractures in post-menopausal women and older men. Cochrane Database Syst Rev. 2014;2014(4). https://doi.org/10.1002/14651858.CD000227.pub4

25. Zhao J-G, Zeng X-T, Wang J, et al. Association Between Calcium Or Vitamin D Supplementation and Fracture Incidence in Community-Dwelling Older Adults: A Systemic Review and Meta-analysis. JAMA. 2017;318(24):2466–82. https://doi.org/10.1001/jama.2017.19344

26. Martineau AR, Jolliffe DA, Greenberg L, et al. Vitamin D supplementation to prevent acute respiratory infections: Individual participant data meta-analysis. Health Technol Assess. 2019;23(2):1–44. https://doi.org/10.3310/hta23020

27. Płudowski P, Karczmarewicz E, Bayer M, et al. Practical guidelines for the supplementation of vitamin D and the treatment of deficits in Central Europe—recommended vitamin D intakes in the general population and groups at risk of vitamin D deficiency. Endokrynol Pol. 2013;64(4):319–27. https://doi.org/10.5603/ep.2013.0012

28. Holick MF, Binkley NC, Bischoff-Ferrari HA, et al. Endocrine Society: Evaluation, treatment and prevention of vitamin D deficiency: an endocrine society, clinical practice guideline. J Clin Endocrinol Metab. 2011;96(7):1911–30. https://doi.org/10.1210/jc.2011-0385