Journal of Steroid Biochemistry and Molecular Biology 197 (2020) 105523

Contents lists available at ScienceDirect

Journal of Steroid Biochemistry and Molecular Biology

journal homepage: www.elsevier.com/locate/jsbmb

Clinical identification of older adults with hypovitaminosis D: Feasibility, acceptability and accuracy of the 'Vitamin D Status Diagnosticator' in primary care

Jean-Michel Le Moigno[a], Gaëlle Annweiler[a,b], Spyridon N. Karras[c], David J. Llewellyn[d], Jérémie Riou[e,f], Cédric Annweiler[a,b,g,*], on behalf of the SOCOS group

[a] Health Faculty, School of Medicine, Angers, France
[b] Department of Geriatric Medicine, Angers University Hospital, Angers University Memory Clinic, Research Center on Autonomy and Longevity, UPRES EA 4638, University of Angers, Angers, France
[c] Division of Endocrinology and Metabolism, First Department of Internal Medicine, Medical School, Aristotle University of Thessaloniki, AHEPA University Hospital, Thessaloniki, Greece
[d] University of Exeter Medical School, Exeter, UK
[e] INSERM, MINT, 1066, University of Angers, Angers, France
[f] Delegation to Clinical Research and Innovation, Angers University Hospital, Angers, France
[g] Robarts Research Institute, Department of Medical Biophysics, Schulich School of Medicine and Dentistry, The University of Western Ontario, London, Ontario, Canada

ARTICLE INFO

Keywords:
Screening
Vitamin D
Vitamin D deficiency
Older adults
Primary care

ABSTRACT

The 16-item Vitamin D Status Diagnosticator (VDSD) tool was built to diagnose, without resorting to a blood test, hypovitaminosis D among healthy seniors living at home. The objective of this study was to determine the feasibility of the VDSD by general practitioners (GPs), the acceptability to outpatients, and the diagnostic accuracy of the VDSD in primary care. Ten French GPs were asked from March to May 2015 to perform the VDSD in 30 consecutive outpatients aged ≥70years, living at home, presenting with a history of recurrent falls and/or osteomalacia, and taking no vitamin D supplements. Feasibility was defined as a proportion > 70% of VDSD forms fully completed. Completing time, acceptance rate and, when applicable, the reasons for non-completing were assessed, together with the metrological properties of the VDSD to identify hypovitaminosis D ≤75nmol/L, or ≤50nmol/L or ≤25nmol/L. Of the 242 enrolled patients, 218 (mean, 79 ± 6years; 46.3% women) received a VDSD, i.e. completing rate of 90.1%, with an average completing time of 1 min and 48s. The acceptance rate by the patients was 98.8%, and all GPs were satisfied with the tool. The VDSD identified hypovitaminosis D≤75nmol/L with an accuracy of 84.7%, hypovitaminosis D≤50nmol/L with accuracy 75.4%, and hypovitaminosis D≤25nmol/L with accuracy 71.0% (n = 183 assays). The 16-item VDSD can be considered as feasible, acceptable and accurate for diagnosing hypovitaminosis D among older outpatients in primary care without resorting to an expensive blood test.

1. Introduction

Hypovitaminosis D is common among seniors and accompanied by various skeletal and nonskeletal adverse health events [1,2]. Although effective for correcting hypovitaminosis D, universal supplementation remains, however, not recommended due to potential risk of intoxication [3,4] and lack of evidence for cost-effectiveness [5]. While few side effects on phosphocalcic metabolism are reported with vitamin D supplements up to 4000 IU/day [6], other risks such as accidental falls may appear with moderate-to-high doses in individuals who already exhibit desirable vitamin D status [7]. For this reason, determining vitamin D status before initiating supplementation is useful [8], and the use of blood tests increases dramatically, especially in primary care [9]. For instance, 8,061,115 assays of 25-hydroxyvitamin D (25OHD) were performed in France in 2012, of which the vast majority (n = 6,183,825; 77%) were prescribed in primary care [9]. Given the relatively high cost of these blood tests, and to prevent insurmountable health costs in the future, new strategies should be urgently developed to detect older community-dwellers with hypovitaminosis D without resorting to a blood test. In this perspective, we recently built the

* Corresponding author at: Department of Geriatric Medicine, Angers University Hospital, 49933, Angers Cedex 9, France.
E-mail address: Cedric.Annweiler@chu-angers.fr (C. Annweiler).

https://doi.org/10.1016/j.jsbmb.2019.105523
Received 18 July 2019; Received in revised form 11 October 2019; Accepted 29 October 2019
Available online 02 November 2019
0960-0760/

Vitamin D Status Diagnosticator (VDSD), a 16-item questionnaire with algorithm able to accurately identify, among older community-dwellers, those with vitamin D insufficiency (i.e., serum 25OHD concentration ≤75nmol/L) [1,2] and deficiency (i.e., serum 25OHD concentration ≤25nmol/L) who may be administered vitamin D supplements without blood test [10]. However, although the VDSD tool was designed for everyday practice, its feasibility in primary care has not been examined yet. Also, the tool was developed in healthy seniors living at home, but its diagnostic accuracy in outpatients (i.e., in a context of healthcare) remains unknown. We hypothesized that the VDSD tool is both feasible and accurate in primary care to identify older adults with hypovitaminosis D. Our main objective was to determine the feasibility of the VDSD by general practitioners (GPs) and the acceptability to patients in primary care. Our secondary objective was to determine the diagnostic accuracy of the VDSD tool for the identification of older patients with hypovitaminosis D in primary care.

2. Materials and methods

2.1. Participants

We studied outpatients recruited in the VDSD-PC (Vitamin D Status Diagnosticator for Primary Care) study. The VDSD-PC study is an observational study designed to apply the VDSD among outpatients seen in consultation by ten GPs in the great western France from 20 March 2015 to 22 May 2015. Each participating GP was asked to enrol the first 30 outpatients aged 70 and over, living at home, and presenting with a history of recurrent falls and / or suspicion of osteomalacia. Of note, history of falls and osteomalacia are the two main indications for 25OHD assay adopted by the National Authority for Health in France (HAS) [9]. Exclusion criterion was current vitamin D supplementation. After giving their informed consent for research, included participants received a full medical examination consisting of a blood test, structured questionnaires and a standardized clinical examination. The study was conducted in accordance with the ethical standards set forth in the Helsinki Declaration (1983). The entire study protocol was approved by the local Ethical Committee (No 2015-02).

2.2. Vitamin D status diagnosticator

Included participants underwent a full clinical examination by a physician. The following 16 items from the original VDSD were collected in a standardized manner [10]: gender, age (in years), number of therapeutic classes used per day, body mass index (BMI, in kg/m^2), use walking aids, use psychoactive drugs (i.e., benzodiazepines, anti-depressants or neuroleptics), wearing glasses, sad mood, fear of falling, history of falls in the preceding year, cognitive disorders, undernutrition, polymorbidity, history of vertebral fractures, living alone, use anti-osteoporotic substances (e.g. bisphosphonates, strontium or calcium supplements). The BMI was calculated based on anthropometric measurements. Undernutrition was defined as BMI below 21 kg/m^2 and / or serum albumin concentration below 35 g/L [11]. Polymorbidity was defined as having more than three chronic diseases (i.e., diseases of indefinite duration or running a course with minimal change). A fall was defined as an event resulting in a person coming to rest unintentionally on the ground or at other lower level, not as the result of a major intrinsic event or an overwhelming hazard, according to the French society of geriatrics and gerontology (SFGG) and the French HAS [12]. The history of vertebral fractures was sought for patients' and relatives' interview and from the medical records. The fear of falling was sought using the following standardized question "Are you afraid of falling?", as previously published [13]. The presence of cognitive disorders was identified using the Mini-Mental State Examination [14] and/or the history of dementia with or without delirium from medical records. Finally, sad mood was sought using the following question from the 4-item Geriatric Depression Scale: "Do you feel discouraged and sad?" [15].

2.3. Feasability

The primary endpoint was the completing rate of the VDSD administered by GPs. The completing rate was calculated as the percentage of VDSD forms fully completed on the number of patients recruited. Feasibility was defined as completing rate > 70%. We also assessed the completing time of the VDSD (in minutes). Finally, at the end of the study, a standardized questionnaire was administered by one author (JLM) to each participating GP during a face-to-face interview. The questions focused on their overall feeling about the VDSD tool including questions on their feelings about the simplicity and completing time, questions about the potential use of the VDSD on a routine basis, and the possible impact on the search for hypovitaminosis D in outpatients.

2.4. Acceptability

The endpoints were i) the acceptance rate in patients, and ii) when applicable, the reasons for not completing the VDSD including the omission and the lack of time.

2.5. Diagnostic accuracy

Venous blood was collected for the measurement of serum 25OHD concentration by radioimmunoassay in various laboratories during the week following the VDSD assessment. Interlaboratory measurement variability improved in recent years thanks to the DEQAS program (International vitamin D quality assessment scheme), even if inter-technical variability persists. This inter-technical variability justifies following the changes of 25OHD concentrations using the same technique, but not necessarily within the same laboratory [16]. The intra- and interassay precisions of radioimmunoassay were 5.2% and 11.3%, respectively (range 30–125 nmol/L in normal adults aged 20–60 years). Based on previous literature, three different threshold values were used consecutively to define hypovitaminosis D: 25, 50, and 75 nmol/L (to convert to ng/mL, divide by 2.496). Finally, we applied the algorithm previously published [10] to the 16 items of the VDSD in order to identify among participants those with hypovitaminosis D (i.e., with serum 25OHD ≤ 25, or ≤50, or ≤75 nmol/L), without knowledge of the blood test result [1].

2.6. Statistical analysis

The GPs' and participants' characteristics were summarized using frequencies and percentages or means ± standard deviations, as appropriate. The feasibility and acceptability of the VDSD were described among the whole sample of participants. Finally, the metrological properties of the VDSD tool were evaluated for the identification of hypovitaminosis D in all outpatients with a blood test. P-values < 0.05 were considered significant. All statistics were performed using SPSS (v19.0, IBM Corporation, Chicago, IL), R 3.1.0 (GNU project), NetBeans IDE 8.0, and Dag-stat [17].

3. Results

Of ten GPs solicited (four women and six men; 13.2 ± 12.4 years of practice on average), all participated in the VDSD-PC study and enrolled at least one patient. Nine GPs were incumbents, and one was a substitute physician. Seven physicians were practicing in semi-rural areas, two in rural areas, and one in an urban area. The mean number of patients included by every physician was 24.2 ± 8.2. The mean interval between the first and the last inclusion was 53.6 ± 12.7 days (range, 25–63 days).

Among the 242 outpatients who met the inclusion criteria, the

Table 1
Participants data (n = 218).

Characteristics	Cohort	
	Summary value	(95% CI)
Item 1- Female gender	101 (46.3)	(39.7 ; 59.9)
Item 2- Age, years	78.8 ± 5.6 [70 – 101]	(78.0 ; 79.5)
Item 3- Number of drugs daily taken	4.5 ± 3.0 [0 – 16]	(4.1 ; 4.9)
Item 4- Body mass index, kg/m^2	26.9 ± 4.3 [16.4 – 42.0]	(26.3 ; 27.4)
Item 5- Use walking aids	34 (15.6)	(10.8 ; 20.4)
Item 6- Use psychoactive drugs	64 (29.4)	(23.4 ; 35.5)
Item 7- Wearing glasses	170 (78.0)	(72.5 ; 83.5)
Item 8- Sad mood	49 (22.5)	(20.0 ; 28.0)
Item 9- Fear of falling	71 (32.6)	(26.4 ; 38.8)
Item 10- History of falls	62 (28.4)	(22.4 ; 34.4)
Item 11- Cognitive disorders	19 (8.7)	(5.0 ; 12.4)
Item 12- Undernutrition	15 (6.9)	(3.5 ; 10.3)
Item 13- Polymorbidity	111 (50.9)	(44.3 ; 57.5)
Item 14- History of vertebral fractures	14 (6.4)	(3.2 ; 9.7)
Item 15- Living alone	58 (26.6)	(20.7 ; 32.5)
Item 16- Use anti-osteoporotic substances	2 (0.9)	(0.0 ; 2.2)
25-hydroxyvitamin D, nmol/L*	45.1 ± 23.9 [3.6 – 158.3]	(41.6 ; 48.6)
Hypovitaminosis D ≤ 75 nmol/L*	162 (74.3)	(68.0 ; 80.6)
Hypovitaminosis D ≤ 50 nmol/L*	119 (54.6)	(47.4 ; 61.8)
Hypovitaminosis D ≤ 25 nmol/L*	40 (18.3)	(12.7 ; 23.9)

Data presented as mean ± standard deviation [range] or n (%) where applicable. CI: confidence interval; *: data available for 183 participants.

VDSD was completed in 218 individuals (mean ± standard deviation, 79 ± 6years; 46.3% female). Among them, 183 patients (mean , 79 ± 6years; 45.9% female) had a blood test for the measure of the serum 25OHD concentration (mean, 45.1 ± 23.9 nmol/L). Among these 183 participants, 162 (74.3%) had serum 25OHD ≤ 75nmol/L, 119 (54.6%) had 25OHD ≤ 50nmol/L, and 40 (18.3%) had 25OHD ≤ 25nmol/L (Table 1).

Table 2 shows that the completing rate was 90.1% (i.e. greater than the 70% expected) meaning that the VDSD tool could be considered as feasible. The mean completing time was 1 min and 48 s (range 1–5 minutes). Interestingly, the completing time was inversely correlated to the number of years of practice (r = -0.18, P = 0.006). Regarding the reasons for not completing the VDSD, only three patients refused the VDSD (1.2%); one patient because s/he was tired, the other one because s/he did not feel concerned, and the last one without giving any explanation. In parallel, two questionnaires (0.8%) were not completed because the physicians considered it was not feasible in the clinical context, eight (3.3%) due to omission, and eleven (4.5%) due to lack of time. The latter eleven instances involved seven physicians out of the ten who took part in the study.

Table 2
Feasibility and acceptability of the VDSD tool.

	Summary value
Feasibility	
Completing rate*, %	218 (90.1)
Completing time†, min	1.8 ± 0.7
Acceptability*	
Patients acceptance rate	239 (98.8)
Reasons for non-completing the VDSD (n = 24)	
Patient refusal	3 (1.2)
Infeasible in the clinical context	2 (0.8)
Physician lack of time	11 (4.5)
Physician omission	8 (3.3)
Physicians satisfaction‡	19 (8.7)
Physicians globally satisfied with the VDSD	10 (100)
Physicians satisfied with the completing time	10 (100)
Physicians finding the VDSD easy to use	10 (100)
Physicians considering the VDSD usable on a routine basis	9 (90)
Physicians likely to use the VDSD on a routine basis	8 (80)
Physicians likely to seek more frequently hypovitaminosis D in their patients if they had the tool	7 (70)

Data presented as mean ± standard deviation or n (%) where applicable. *: data available for 242 participants; †: data available for 218 participants; ‡: data available for 10 participants.

Regarding their feeling towards the VDSD, all physicians were satisfied with the tool, with the completing time, and found it easy to use. Nine out of ten would consider using it in everyday practice, and eight would be particularly prone to use it. Finally, although only three GPs reported to seek hypovitaminosis D ordinarily before the study, four additional GPs (total, seven GPs) thought they would be more likely to seek hypovitaminosis D in their patients with the VDSD tool (Table 2).

Finally, Table 3 reports the metrological properties of the VDSD for the identification of hypovitaminosis D in this sample. The best (i.e., highest) performance was found for the diagnosis of hypovitaminosis D ≤ 75nmol/L (diagnostic accuracy 84.7%, with positive likelihood ratio 2.1 and negative likelihood ratio 4.9). The VDSD was also effective in diagnosing hypovitaminosis D ≤ 50nmol/L and hypovitaminosis D ≤ 25nmol/L, although with lower accuracy (respectively, 75.4% and 71.0%) (Fig. 1). The OR for hypovitaminosis D ≤ 75nmol/L was 10.0 [95% confidence interval (CI): 3.7–27.0] while using 'not combining items' as a reference, OR = 7.7 [95CI: 3.9–15.5] for hypovitaminosis D ≤ 50nmol/L, and OR = 6.3 [95CI: 2.9–13.9] for hypovitaminosis D ≤ 25nmol/L (Fig. 1).

4. Discussion

Our results showed that the 16-item VDSD was feasible, acceptable and accurate to identify hypovitaminosis D among older outpatients in primary care.

Although numerous studies have examined the variables influencing the serum 25OHD concentration, only few were designed to identify hypovitaminosis D among older adults, and mainly in academic or hospital contexts [18–21], but not in primary care. Moreover the feasibility and acceptability of such procedures have not yet been examined. Thus the present study complements previous literature by providing the first evidence that our VDSD tool is feasible and acceptable to patients, and was accurate during primary care consultation.

The short and noninvasive VDSD questionnaire was very well accepted to patients. The acceptance rate, which amounted to 98.8%, showed that the majority of non-completed VDSD questionnaires were related to physicians due to a lack time (45.8%) or omission (33.3%).

Table 3
Metrological properties of the VDSD tool for the diagnosis of hypovitaminosis D according to the different threshold values (n = 218).

Hypovitaminosis D	True positive	False positive	True negative	False negative	Sensitivity, %	Specificity, %	Positive predictive value	Negative predictive value	Positive likelihood ratio	Negative likelihood ratio	Accuracy, %
≤ 75 nmol/L	143	9	12	19	88.3	57.1	94.1	38.7	2.1	4.9	84.7
≤ 50 nmol/L	99	25	39	20	83.2	60.9	79.8	66.1	2.1	3.6	75.4
≤ 25 nmol/L	29	42	101	11	72.5	70.6	40.9	90.2	2.5	2.6	71.0

Stressing the physicians' lack of time may appear contradictory with the relatively short completing time of less than 2 min, but GPs indicated that their impression of lack of time was mainly due to delays in the consultations that could be considerable. They added that the VDSD tool appeared particularly suited for consultations aimed at renewing the patients' treatments, which are usually more amenable to the patient global assessment.

GPs were globally satisfied with the VDSD tool. The strengths they identified were the following: i) the VDSD is a relatively standard questionnaire, thus easy to integrate into everyday practice; ii) the completing time was short since most items were already known by GPs; and iii) the VDSD gave the opportunity to less experienced physicians to address the issues of falls, autonomy and mood. Instead, the limitations they identified were as follows: i) there is a need to incorporate the VDSD into a software for the calculation of the risk of hypovitaminosis D; ii) using the VDSD was difficult during the consultations for acute organic decompensations; and iii) the VDSD would be an additional unlisted act in primary care. Overall, the majority of GPs would be willing to use the VDSD in routine consultations, and even 70% felt that they would seek more frequently hypovitaminosis D in their patients with this tool because they would get the result immediately without the delay of the blood test and because its diagnostic accuracy was high.

The VDSD was able to identify hypovitaminosis D among older outpatients in primary care (Table 3 and Fig. 1). Age-related hypovitaminosis D is all the more prejudicial in this population as it is highly frequent and it results in various adverse health events including osteomalacia, propensity to fall, diabetes mellitus, cognitive disorders, cancers, sarcopenia and viral infections, among others [1,2]. Importantly, hypovitaminosis D and related adverse events may be corrected by oral supplementation [22,23], of which the dose and schedule depend on the identification of hypovitaminosis D [8]. However, currently, the only way to detect hypovitaminosis D relies on blood tests, which are expensive and whose results are available only after a waiting period. That is why, to rationalize the use of serum 25OHD assays and to save health costs, clinical diagnostic tools like the VDSD are needed to identify individuals at high risk of hypovitaminosis D; the blood tests being then restricted to people whose vitamin D status remains indeterminate. Moreover, since 75 nmol/L is the broadest definition of hypovitaminosis D [1], it is likely that our VDSD tool, which is particularly accurate for the identification of hypovitaminosis D ≤ 75nmol/L (Fig. 1), will be valuable and helpful for the clinicians in decisions to supplement their patients. This is the most important difference with other tools built for the same purpose [20,21], which are especially effective for identifying hypovitaminosis D ≤ 25nmol/L, and therefore miss people with serum 25OHD concentration between 25 and 75 nmol/L for whom starting vitamin D supplementation would, however, be appropriate. Here, our VDSD tool was able to diagnose vitamin D status ≤ 75nmol/L, which corresponds to all concentrations ranging between 0 and 75 nmol/L, and exposes individuals to all skeletal and nonskeletal events accompanying low levels of vitamin D [1,2].

Some limitations should be acknowledged. First, the study cohort was restricted to outpatients with a history of falls or osteomalacia who were probably frailer and with lower 25OHD concentrations than the population of all older outpatients. It is also possible that they have been more accepting of the VDSD as they had a history of falls or osteomalacia and thus possibly a better understanding of the importance of vitamin D compared to a wider sample of patients. Second, it is possible that participating GPs may not be representative of the entire profession, although several generations were selected with a variety of years of experience, and both rural and urban practices were represented. Third, our sample size was relatively small and could not be calculated *a priori*. Fourth, the inclusion period from March to May may have influenced the proportion of hypovitaminosis D here. However, it is noticeable that, unlike the present study, the VDSD tool was initially built (and its metrological qualities examined) from blood tests carried out throughout the year [10], including at the end of summer / beginning of autumn during which the 25OHD concentrations are the highest in France.

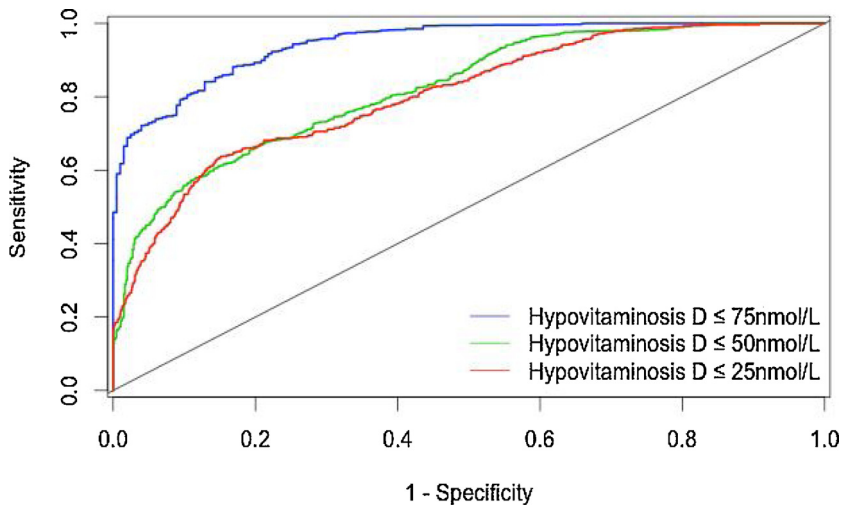

Fig. 1. ROC curves for the diagnosis of hypovitaminosis D with the VDSD tool, according to the different definitions of hypovitaminosis D.

5. Conclusions

In conclusion, the 16-item VDSD was feasible, acceptable and accurate for identifying hypovitaminosis D among older outpatients in primary care. Such an inexpensive and noninvasive tool may undoubtedly help GPs in decisions to supplement their geriatric patients without routinely resorting to an expensive blood test. Additional studies are needed to determine the cost-effectiveness of the tool, and its efficiency for replacing monitoring blood tests after the initiation of vitamin D supplements. Future steps are to provide the tool on a larger scale for consultations using dedicated computerized support.

Authors contribution

- CA has full access to the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analyses.
- Study concept and design: CA.
- Acquisition of data: JLM and GA.
- Analysis and interpretation of data: GA, CA, JLM, DJL and JR.
- Drafting of the manuscript: CA, JLM and GA.
- Critical revision of the manuscript for important intellectual content: SNK, DJL and JR.
- Obtained funding: Not applicable.
- Statistical expertise: CA and JR.
- Administrative, technical, or material support: CA.
- Study supervision: CA.

Sponsor's role

None.

Declaration of Competing Interest

The authors report no conflict of interest with this manuscript. They have no relevant financial interest in this manuscript.

Acknowledgment

We are grateful to the participants and general practitioners for their cooperation.

References

[1] M.F. Holick, Vitamin D deficiency, N. Engl. J. Med. 357 (2007) 266–281.
[2] P. Pludowski, M.F. Holick, S. Pilz, et al., Vitamin D effects on musculoskeletal health, immunity, autoimmunity, cardiovascular disease, cancer, fertility, pregnancy, dementia and mortality-a review of recent evidence, Autoimmun. Rev. 12 (2013) 976–989.
[3] W.B. Grant, S.N. Karras, H.A. Bischoff-Ferrari, et al., Do studies reporting' U'-shaped serum 25-hydroxyvitamin D-health outcome relationships reflect adverse effects? Dermatoendocrinology 8 (2016) e1187349.
[4] C. Annweiler, G. Duval, C.P. Launay, Estimating vitamin D status and the choice of supplementation dose, JAMA Intern. Med. 176 (2016) 865.
[5] R.H. Lee, T. Weber, C. Colón-Emeric, Comparison of cost-effectiveness of vitamin D screening with that of universal supplementation in preventing falls in community-dwelling older adults, J. Am. Geriatr. Soc. 61 (2013) 707–714.
[6] T. Araki, M.F. Holick, B.D. Alfonso, et al., Vitamin D intoxication with severe hypercalcemia due to manufacturing and labeling errors of two dietary supplements made in the United States, J. Clin. Endocrinol. Metab. 96 (2011) 3603–3608.
[7] H.A. Bischoff-Ferrari, B. Dawson-Hughes, E.J. Orav, et al., Monthly high-dose vitamin D treatment for the prevention of functional decline: a randomized clinical trial, JAMA Intern. Med. 176 (2016) 175–183.
[8] R.Y. van der Velde, J.R. Brouwers, P.P. Geusens, W.F. Lems, J.P. van den Bergh, Calcium and vitamin D supplementation: state of the art for daily practice, Food Nutr. Res. (2014) 58.
[9] French National Authority for Health, Clinical Utility of the Measurement of Vitamin D, Haute Autorité de Santé (HAS), Saint-Denis, 2013 Available from: http://www.has-sante.fr/portail/jcms/c_1356838/fr/utilite-clinique-du-dosage-de-la-vitamine-d-rapport-d-evaluation. Accessed 14 July 2019.
[10] C. Annweiler, A. Kabeshova, M. Legeay, B. Fantino, O. Beauchet, Derivation and validation of a clinical diagnostic tool for the identification of older community-dwellers with hypovitaminosis D, J. Am. Med. Dir. Assoc. 16 (536) (2015) e8–19.
[11] French National Authority for Health, Stratégie de prise en charge en cas de dénutrition protéinoénergétique chez la personne âgée, (2007) Available from: http://www.hassante.fr/portail/jcms/c_546549/strategie-de-prise-en-charge-en-cas-de-denutritionproteino-energetique-chez-la-personne-agee . Accessed July 14, 2019.
[12] O. Beauchet, V. Dubost, C. Revel Delhom, G. Berrut, J. Belmin, French Society of Geriatrics and Gerontology, How to manage recurrent falls in clinical practice: guidelines of the French Society of Geriatrics and Gerontology, J. Nutr. Health Aging 15 (2011) 79–84.
[13] F. Ayoubi, C.P. Launay, C. Annweiler, O. Beauchet, Fear of falling and gait variability in older adults: a systematic review and meta-analysis, J. Am. Med. Dir. Assoc. 16 (2015) 14–19.
[14] M.F. Folstein, S.E. Folstein, P.R. McHugh, "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician, J. Psychiatr. Res. 12 (1975) 189–198.
[15] A. Shah, R. Herbert, S. Lewis, R. Mahendran, J. Platt, B. Bhattacharyya, Screening for depression among acutely ill geriatric inpatients with a short Geriatric Depression Scale, Age Ageing 26 (1997) 217–221.
[16] C. Annweiler, E. Legrand, J.C. Souberbielle, Vitamin D in adults: update on testing and supplementation, Geriatr. Psychol. Neuropsychiatr. Vieil 16 (2018) 7–22.
[17] A. Mackinnon, A spreadsheet for the calculation of comprehensive statistics for the assessment of diagnostic tests and inter-rater agreement, Comput. Biol. Med. 30 (2000) 127–134.
[18] G. Chevallereau, X. Gleyses, L. Roussel, S. Hamdan, O. Beauchet, C. Annweiler, Proposal and validation of a quick question to rate the influence of diet in geriatric epidemiological studies on vitamin D, Int. J. Vitam. Nutr. Res. 83 (2013) 254–258.
[19] S. Hamdan, L. Roussel, X. Gleyses, et al., Detection of hypovitaminosis D in older adults: a classification tree analysis, J. Am. Geriatr. Soc. 62 (2014) 1193–1195.
[20] T. Merlijn, K.M.A. Swart, P. Lips, et al., Prediction of insufficient serum vitamin D status in older women: a validated model, Osteoporos. Int. 29 (2018) 1539–1547.
[21] M. Deschasaux, J.C. Souberbielle, V.A. Andreeva, et al., Quick and easy screening for vitamin D insufficiency in adults: a scoring system to be implemented in daily clinical practice, Medicine (Baltimore) 95 (2016) e2783.
[22] J.E. Manson, N.R. Cook, I.M. Lee, et al., Vitamin D supplements and prevention of Cancer and cardiovascular disease, N. Engl. J. Med. 380 (2019) 33–44.
[23] A.G. Pittas, B. Dawson-Hughes, P. Sheehan, et al., Vitamin D supplementation and prevention of type 2 diabetes, N. Engl. J. Med. 381 (2019) 520–530.