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Osteoporosis as a risk factor for the development of benign paroxysmal positional vertigo

Osteoporoza kao čimbenik rizika za razvoj benigne paroksizmalne položajne vrtoglavice

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Summary

Objectives: The aim of this study is to examine the association of vitamin D levels, ionized calcium, and densitometry findings with the onset of BPPV.

Participants and methods: A cross-sectional study was conducted, including 40 subjects over the age of 18 who were diagnosed with BPPV based on a positive result of the Dix-Hallpike maneuver. Clinical assessments were performed by an otorhinolaryngology specialist. Subjects with a confirmed diagnosis of BPPV were further referred for laboratory tests to measure vitamin D levels, ionized calcium in the blood, and bone densitometry.

Results: Out of 40 subjects, 37 (93%) were women, and 3 (7%) were men. In all cases, the posterior semicircular canal was involved. The right side was affected in 23 subjects (58%). Osteopenia and osteoporosis were recorded in 34 subjects (85%). Reference range values for vitamin D were recorded in 19 subjects (4%), while ionized calcium levels were within the reference range in 7 subjects (18%). Sixteen subjects (40%) had both values within the reference range. No significant associations were found between gender, clinical form, or affected side and the values of vitamin D, calcium, or densitometry findings.

Conclusion: However, an association was observed between the presence of osteoporosis and BPPV, suggesting that osteoporosis may be a risk factor for the development of BPPV. The study could not establish the influence of low vitamin D or ionized calcium levels on the development of BPPV. Further research is needed to better understand these potential relationships.

Keywords: benign paroxysmal positional vertigo; densitometry; ionizing calcium; osteoporosis; vitamin D

Sažetak

Cilj istraživanja: Cilj ovoga istraživanja je ispitati povezanost razine vitamina D, ionizirajućeg kalcija i nalaza denzitometrije s nastankom BPPV-a.

Ispitanici i metode: Provedeno je presječno istraživanje. U istraživanje je uključeno 40 ispitanika starijih od 18 godina kojima je dijagnoza BPPV-a postavljena na temelju pozitivnog rezultata Dix-

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Hallpikeova manevra. Procjenu kliničkog statusa određivao je specijalist otorinolaringologije, a ispitanici s dokazanom dijagnozom BPPV-a bili su upućeni na sljedeće pretrage: laboratorijsko određivanje razine vitamina D, ionizirajućeg kalcija u krvi i denzitometriju.

Rezultati: Od ukupno 40 ispitanika, 37 (93 %) je žena i tri (7 %) muškarca. Kod svih ispitanika radi se o zahvaćenosti stražnjeg polukružnog kanalića. Desna strana je zahvaćena kod 23 (58 %) ispitanika. Osteopenija i osteoporoza zabilježene su kod 34 (85 %) ispitanika. Vrijednosti vitamina D u rasponu referentnih vrijednosti bilježe se kod 19 (4 %) ispitanika, a ionizirajućeg kalcija kod njih 7 (18 %). I jednu i drugu vrijednost u referentnom intervalu ima 16 (40 %) ispitanika. Nema značajne povezanosti između spola, kliničkog oblika i zahvaćene strane s vrijednostima vitamina D, kalcija i nalaza denzitometrije.

Zaključak: Uočena je povezanost između prisutnosti osteoporoze i BPPV-a, tako da se može zaključiti kako je osteoporoza jedan od čimbenika rizika za razvoj BPPV-a. Međutim, iz dobivenih rezultata nije se mogao ispitati utjecaj niske razine vitamina D i ionizirajućeg kalcija na nastanak BPPV-a. Potrebna su daljnja istraživanja kako bi se bolje razumjeli ovi potencijalni odnosi.

Ključne riječi: benigna paroksizmalna položajna vrtoglavica; denzitometrija; ionizirajući kalcij; osteoporoza; vitamin D

Introduction

Benign paroxysmal positional vertigo (BPPV) accounts for approximately 20–40% of all cases of peripheral vertigo in the general population. It is characterized by brief but intense episodes of vertigo triggered by changes in the head position.[1,2,3] Although BPPV often resolves spontaneously within a few weeks or months, it can also become chronic or recurrent. The disease occurs when tiny calcium carbonate crystals, known as otoliths or otoconia, become dislodged from the utricle, typically due to degenerative processes or trauma. When the head moves into a position aligned with gravity, the otoliths migrate into one of the semicircular canals, most often the posterior canal. In this location, the otoliths stimulate the cupula, causing symptoms such as brief episodes of vertigo, nausea, and positional nystagmus.[4]

In older adults, the prevalence of BPPV exceeds 50%, owing to the continuous degradation of the maculae of the sensory otolith organs of the vestibule.[5] The same authors emphasize the most common causes that were reported included adverse reactions to medication (11.3%), infections of the inner ear (11.0%), heart disease (8.6%) and loose otoliths (7.9%), which probably indicates a diagnosis of BPPV.

An epidemiological study conducted by von Brevern et al. in the adult population of Germany reported a lifetime prevalence of 3.2% in women, 1.6% in men, and 2.4% overall, with an annual incidence of 0.6% (6). BPPV is most common among older women, peaking in incidence during their sixties. Recurrences are frequent, with an annual rate of 15–20% (1). Many clinical studies have found a higher incidence of involvement of the right posterior semicircular canal compared to the left, often attributed to the tendency to sleep on the right side.[6,7]

Osteopenia is a term to define bone density that is not normal but also not as low as osteoporosis.[8] Osteoporosis, a chronic metabolic disease, is characterized by low bone mass, progressive deterioration of bone microarchitecture, and increased bone fragility.[9] By definition from the World Health Organization osteopenia is defined by bone densitometry as a T score -1 to -2.5 and osteoporosis having a T-score >2.5 standard of deviations below the peak bone mass.[8] Several studies have identified a link between BPPV, osteoporosis, and vitamin D deficiency, suggesting that abnormal calcium metabolism may contribute to otolith detachment. Calcium metabolism plays a crucial role in the synthesis and maintenance of otoliths, which are composed of calcium carbonate crystals. Bone mineral density (BMD) serves as an indirect indicator of osteoporosis, while vitamin D plays a key role in bone regeneration by regulating the absorption of calcium and phosphate from the small intestine. Deficiency in vitamin D can cause structural changes in otoliths, predisposing them to detachment and migration, which may consequently lead to the development of BPPV.[10]

This study is based on establishing the association between vitamin D levels, ionized calcium, and densitometry findings, and ultimately osteoporosis as risk factors for the development of benign paroxysmal positional vertigo. As already mentioned, various studies have proven this association.

Participants and methods

The study included subjects over the age of 18 who were presented to the Department of Audiology and Phoniatrics at the Clinic for Otorhinolaryngology and Head and Neck Surgery, University Hospital Center Osijek, due to specific balance disorders. All the participants were diagnosed with BPPV based on

a subjective and objective positive Dix-Hallpike maneuver (Dix-Hallpike test in BPPV with and without nystagmus: positive objective, when there is nystagmus associated with vertigo, positive subjective when there is only vertigo and negative in the absence of nystagmus and vertigo). All the participants gave their signed consent for collecting the data. The study design was approved by the Ethics Committees of Osijek Clinical Hospital Center and the Faculty of Medicine of Osijek (Approval number: 2158-61-46-23-95).

All subjects underwent a clinical examination, the Dix-Hallpike maneuver, and audiological and vestibular evaluations.

The first exclusion criteria were the presence of comorbid conditions with BPPV, including a confirmed diagnosis of Meniere's disease, migraine-associated vertigo, or labyrinthine paresis/paralysis. Additional exclusion criteria included low intellectual or literacy levels, contraindications to performing the Brandt-Daroff repositioning procedure and exercises, and failure to adhere to the prescribed diagnostic and therapeutic protocols.

The sample was collected during 2021 and 2022, with an expected size of 40 subjects. In the past year, none of the participants had taken vitamin D supplements in any form.

Subjects with a confirmed diagnosis of BPPV were further referred for laboratory tests, including assessments of vitamin D levels, ionized calcium in the blood, and densitometry.

Statistical analysis

Categorical data were presented as absolute and relative frequencies. Differences in categorical variables were tested using the χ^2 test. The normality of the distribution of numerical variables was assessed using the Shapiro-Wilk test. Numerical data were described using the median and interquartile range (IQR) boundaries. The Mann-Whitney test was used to compare numerical variables between the control group and subjects with LPR. Differences in numerical variables within the LPR group before and after three months of therapy were tested using the Wilcoxon test. The strength of associations was expressed using Spearman's correlation coefficient (Rho). All P-values were two-sided, with the significance level set at $\alpha = 0.05$. Statistical analyses were conducted using MedCalc® Statistical Software version 20.218 (MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org; 2023) and SPSS version 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.).

Results

The study included 40 subjects diagnosed with BPPV, of whom 37 (93%) were women and 3 (7%) were men. The median age of the subjects was 68 years (interquartile range: 60–73 years), with ages ranging from 41 to 84 years.

The posterior semicircular canal was involved in all subjects, with the right side affected in 23 subjects (58%). None of the subjects had a history of head trauma. The result of densitometry, a T score above -2.5 was observed in 34 subjects (85%), and based on the endocrinologist's assessment, osteoporosis was diagnosed in 34 subjects (85%) as well (Table 1).

Table 1 Basic characteristics of the subjects
Tablica 1. Osnovna obilježja ispitanika

	Subjects (%) *Ispitanici (%)*
Gender/*Spol*	
Men/*Muškarci*	3 (7)
Women/*Žene*	37 (93)
Semicircular canal/ *Polukružni kanalić*	
Posterior/*Stražnji*	40 (100)
Affected side/*Zahvaćena strana*	
Right/*Desno*	23 (58)
Left/*Lijevo*	17 (42)
Previous head trauma/ *Prethodne traume glave*	
No head trauma/*Bez traume glave*	40 (100)
Clinical form of BPPV/ *Klinički oblik BPPV*	
Canalolithiasis/*Kanalolitijaza*	32 (80)
Cupulolithiasis/*Kupulolitijaza*	8 (20)
Densitometry/*Denzitometrija*	
Normal result/*Uredan nalaz*	6 (15)
Osteoporosis /*Osteoporoza*	34 (85)
Findings of the endocrinologist/ *Nalaz endokrinologa*	
Osteoporosis positive/ *Osteoporoza pozitivna*	34 (85)
Osteoporosis negative/ *Osteoporoza negativna*	6 (15)

The number of repositioning procedures ranged from 2 to 5, and vitamin D concentrations from 9.6 to 60.6. The median value of ionized calcium was 2.45 (Table 2). There were no significant differences in the distribution of subjects according to vitamin D values within reference values, ionized calcium, and densitometry findings with respect to the affected side (Table 3).

Table 2 Median and standard deviation of the number of repositioning procedures, vitamin D levels, and ionized calcium levels
Tablica 2. Srednja vrijednost i standardna devijacija broja repozicijskih postupaka, te razine vitamina D i ionizirajućeg kalcija

	Median (Interquartile range)/ *Medijan (interkvartilni raspon)*
Number of repositioning procedures/*Broj repozicijskih postupaka*	2 (2 – 2)
Vitamin D/*Vitamin D*	21.10 (17.06 – 29.13)
Ionizing calcium/*Ionizirajući kalcij*	2.45 (2.38 – 2.52)

Vitamin D levels within the reference range were recorded in 19 subjects (48%), while ionized calcium levels were within the reference range in 7 subjects (18%). Both values fell within the reference range in 16 subjects (40%).

Table 3 Distribution of subjects according to vitamin D values within reference values and ionized calcium with respect to the affected side
Tablica 3. Raspodjela ispitanika prema vrijednostima vitamina D unutar referentnih vrijednosti i ionizirajućeg kalcija s obzirom na zahvaćenu stranu

	Number (%) of subjects by affected side/ *Broj (%) ispitanika prema zahvaćenoj strani*			*P*value P*vrijednost*
	Right/*Desno* (n = 23)	Left/*Lijevo* (n = 17)	Total/Ukupno (n = 40)	
Vitamin D/*Vitamin D*				
Reference value/ *Referentna vrijednost*	12 (52)	7 (41)	19 (48)	0.54
Elevated values/ *Povišena vrijednost*	11 (48)	10 (59)	21 (53)	
Ionizing calcium/*Ionizirajući kalcij*				
Reduced values/ *Snižene vrijednosti*	0	1 (6)	1 (3)	0.81
Reference value/ *Referentna vrijednost*	4 (17)	3 (17)	7 (17)	
Elevated values/ *Povišene vrijednosti*	19 (83)	13 (77)	32 (80)	
Vitamin D and ionizing calcium/ *Vitamin D i ionizirajući kalcij*				
Both values are not in the reference interval/ *Obje vrijednosti nisu u referentnom intervalu*	15 (65)	9 (53)	24 (60)	0.52
Reference value/ *Referentna vrijednost*	8 (35)	8 (47)	16 (40)	
Densitometry/*Denzitometrija*				
Normal finding/ *Uredan nalaz*	5 (22)	1 (6)	6 (15)	0.22
Osteoporosis / *Osteoporoza*	18 (78)	16 (94)	34 (85)	

* Fisher's exact test/ *Fisherov egzaktni test*

There is no significant difference in vitamin D and ionized calcium values with respect to the clinical form of BBPV (Table 4).

Table 4 Differences in vitamin D and ionized calcium values with respect to the clinical form of BBPV
Tablica 4. Razlike vrijednosti vitamina D i ionizirajućeg kalcija s obzirom na klinički oblik BBPV-a

	Median (interquartile range)/ *Medijan (interkvartilni raspon)*		*P*value P*vrijednost*
	Canalolithiasis/*Kanalolitijaza* (n = 32)	Cupulolithiasis/*Kupulolitijaza* (n = 8)	
Vitamin D/ *Vitamin D*	21.7 (17.08 – 29.1)	20.9 (17.4 – 30.2)	0.87
Ionizing calcium/ *Ionizirajući kalcij*	2.45 (2.4 – 2.5)	2.44 (2.41 – 2.52)	0.86

* Mann Whitney U test

There are no significant differences in the distribution of subjects according to vitamin D values within reference values, ionized calcium and densitometry findings with respect to the clinical form of BBPV (Table 5).

Table 5 Distribution of subjects according to vitamin D values within reference values and ionized calcium with respect to the clinical form of BBPV
Tablica 5. Raspodjela ispitanika prema vrijednostima vitamina D unutar referentnih vrijednosti i ionizirajućeg kalcija s obzirom na klinički oblik BBPV-a

	Number (%) of subjects according to clinical form of BPPV/ *Broj(%) ispitanika prema kliničkom obliku BPPV-a*			*P*value P*vrijednost*
	Canalolithiasis/ *Kanalolitijaza* (n = 32)	Cupulolithiasis/ *Kupulolitijaza* (n = 8)	Total/ *Ukupno* (n = 40)	
Vitamin D/ *Vitamin D*				
Reference value/ *Referentna vrijednost*	15 (47)	4/8	19 (48)	> 0.99
Elevated values/ *Povišene vrijednosti*	17 (53)	4/8	21 (52)	
Ionizing calcium/*Ionizirajući kalcij*				
Reduced values/ *Snižene vrijednosti*	1 (3)	0	1 (3)	> 0.99
Reference value/ *Referentna vrijednost*	6 (19)	1/8	7 (18)	
Elevated values/ *Povišene vrijednosti*	25 (78)	7/8	32 (80)	
Vitamin D and ionizing calcium/ *Vitamin D i ionizirajući kalcij*				
Both values are not in the reference interval/ *Obje vrijednosti nisu u referentnom intervalu*	19 (59)	5/8	24 (60)	> 0.99
Reference value/ *Referentna vrijednost*	13 (41)	3/8	16 (40)	
Densitometry/*Denzitometrija*				
Normal finding/ *Uredan nalaz*	4 (13)	2/8	6 (15)	0.58
Osteoporosis / *Osteoporoza*	28 (87)	6/8	34 (85)	

*Fisher's exact test/*Fisherov egzaktni test*

Spearman's correlation coefficient was used to examine the association between the age of the subjects and the number of repositioning procedures with vitamin D and ionized calcium levels. It was observed that older subjects had higher vitamin D levels (Rho = 0.437) and higher ionized calcium levels (Rho = 0.316) (Table 6).

Table 6 Distribution of subjects according to vitamin D values within reference values and ionized calcium with respect to the clinical form of BBPV
Tablica 6. Raspodjela ispitanika prema vrijednostima vitamina D unutar referentnih vrijednosti i ionizirajućeg kalcija s obzirom na klinički oblik BBPV-a

	Spearman's correlation coefficient Rho (P value)/ *Spermanov koeficijent korelacije Rho (P vrijednost)*			
	Age/*Dob*	Vitamin D/ *Vitamin D*	Calcium/ *Kalcij*	Number of repositioning procedures/ *Broj repozicijskih postupaka*
Age/*Dob*	-			
Vitamin D/*Vitamin D*	**0.437 (0.005)**	-		
Calcium/*Kalcij*	**0.316 (0.04)**	0.233 (0.15)	-	
Number of repositioning procedures/ *Broj repozicijskih postupaka*	-0.044 (0.79)	-0.035 (0.83)	0.03 (0.84)	-

Bold denotes statistical significance / Podebljano označava statističku značajnost

All subjects have an affected posterior semicircular canal, of which 34 (85%) subjects have osteopenia. There are no significant differences in the number of repositioning procedures, considering whether the subjects have normal densitometry findings or have osteoporosis (Table 7).

Table 7 Differences in the number of repositioning procedures with regard to densitometry findings
Tablica 7. Razlike u broju repozicijskih postupaka s obzirom na nalaz denzitometrije

	Median (interquartile range) according to densitometry results/ *Medijan (interkvartilni raspon) prema nalazu denzitometrije*		*P*value P*vrijednost*
	Normal result/ *Uredan nalaz* (n = 6)	Osteoporosis /*Osteoporoza* (n = 34)	
Number of repositioning procedures/ *Broj repozicijskih postupaka*	2 (2 – 4)	2 (2 – 2)	0.34

*Mann Whitney U test

Discussion

During the course of this study, data were initially collected from 86 patients diagnosed with BPPV based on the Dix-Hallpike maneuver. However, 46 patients were excluded from the study due to insufficient laboratory or endocrinological findings. As a result, 40 subjects remained, all of whom had the necessary findings for conducting the study. The obtained data were statistically analyzed and presented. Of the 40 subjects, only three were male, and the remaining 37 were female. The age range of the subjects was from 41 to 84 years. In most studies on BPPV, the subjects tend to be older women, a trend also observed in the study by Caldas et al. (2009), which found a higher prevalence of BPPV in women between the ages of 41 and 60 years.[11] The higher incidence in women can be explained by the study conducted by Vibert et al., which concluded that hormonal changes in postmenopausal women lead to osteoporosis or osteopenia, thereby altering the structure of the otoliths.[12] Additionally, the influence of age was addressed in the study by Jang et al., which found that aging leads to degenerative changes in the structure of the otoliths.[13]

All subjects included in this study had the most common form of BPPV, which involves the posterior semicircular canal. Canalolithiasis was present in 80% of the subjects, while cupulolithiasis, the less common form, was observed in the remaining subjects. The right side was affected in 58% of the subjects, which is slightly more common than the left. Although many studies report a higher frequency of

right-sided involvement, the results of this study may be influenced by the small sample size.

None of the subjects had experienced previous head trauma, thus excluding it as a potential risk factor for the development of BPPV in this study. Osteopenia was detected by densitometry in 85% of the subjects, and osteoporosis was diagnosed by endocrinology.

In terms of laboratory values, this study did not establish a connection between reduced vitamin D levels and BPPV. Nearly half of the subjects had vitamin D values within the reference range, while the rest had elevated vitamin D levels. The large concentration range of vitamin D, which refers to normal values, should certainly be taken into account. We did not emphasize those subjects who were closer to the lower limit. This contrasts with most studies that emphasize a connection between low vitamin D levels and BPPV. However, a study by Karataş et al. excluded vitamin D deficiency as a risk factor for BPPV, concluding that the association between low vitamin D concentrations and BPPV is coincidental.[14]

Additionally, while many studies link low serum levels of ionized calcium with the development of BPPV, this study did not find such an association. Only one subject had reduced calcium levels; the others either had elevated levels or values within the reference range. Furthermore, several studies highlighted the potential benefits of vitamin D and calcium supplementation in alleviating BPPV symptoms and reducing recurrence rates. One such study by Jeong et al. supported this theory.[15]

Finally, given the high prevalence of osteopenia or osteoporosis among the subjects in this study, we can establish an association between osteoporosis and the development of BPPV. Similar results were reported by Guo et al. (2021), who concluded that osteoporosis is a significant risk factor for BPPV and that calcium metabolism disorders contribute to the development of osteopenia and osteoporosis.[16]

Statistical analysis of the collected data revealed no significant difference in the values of vitamin D and ionized calcium with respect to gender. In 48% of the subjects, vitamin D levels were within the reference range (20.0–100.0 μg/L), while ionized calcium levels were within the reference range (2.14–2.53 mmol/L) in 18% of the subjects. No significant difference was found in the distribution of subjects based on reference values for vitamin D, ionized calcium, or densitometry findings when considering gender. These results are consistent with a study by Thomas et al. (2021), which also recorded no significant difference in vitamin D and calcium levels between men and women.[17]

The Spearman correlation coefficient was used to examine the association between the age of the subjects and their vitamin D and ionized calcium levels. It was observed that older subjects had higher vitamin D and ionized calcium values. However, most studies, such as the one by Sadat-Ali, reported that vitamin D and calcium levels decrease with age.[18] The findings in this study may be explained by factors such as lifestyle, sun exposure, and vitamin D supplementation.

Another goal of this study was to determine the frequency of BPPV on a specific side in subjects with reduced vitamin D levels, ionized calcium, and pathological densitometry findings. The results showed that there was no significant difference in vitamin D, ionized calcium, or densitometry values with respect to the affected side. Additionally, no significant difference was found in the distribution of subjects according to these criteria., 58% of the included subjects had right-sided involvement. While literature generally reports more frequent right-sided involvement, which is often attributed to the habit of sleeping on the right side, Thomas notes that there is no consensus regarding the laterality of BPPV, with many studies showing varying results.[17] Similarly, no significant difference in vitamin D or calcium levels with respect to the affected side were observed in previous studies.

Regarding the clinical form of BPPV in the subjects, it was found that there was no significant difference in the levels of vitamin D and ionized calcium. Argaet et al. (2019) found that canalolithiasis is the more common form of BPPV, which aligns with the data obtained in this study.[19] Patients with both canalolithiasis and cupulolithiasis showed similar values for the aforementioned laboratory parameters. This can be explained by the fact that the cause of otolith detachment is the same in both clinical forms, with the only difference being the location of the detached otolith, which subsequently leads to different symptomatology.

In this study, all patients had BPPV with involvement of the posterior semicircular canal, which is expected given the small sample size and the generally high incidence of posterior canal involvement. Therefore, it was not possible to establish an association between the involvement of a specific semicircular canal and reduced levels of vitamin D or ionized calcium.

Densitometry showed that 85% of the subjects had osteopenia. This finding is supported by a 2019 study by He et al., which demonstrated that the frequency of osteopenia in BPPV patients was significantly higher compared to the control group.[20]

Vitamin D and ionized calcium levels had no significant effect on the number of repositioning

procedures performed. For the majority of patients, two repositioning procedures were sufficient to alleviate symptoms. This success can be attributed to the high efficiency of the Epley repositioning procedures, which was also observed by Uz and colleagues in their 2019 study. In addition to confirming that two repositioning procedures are typically sufficient, their study also showed a significant improvement in the quality of life following the procedures.[21]

Several studies, including one by Ke et al., have identified osteopenia as an important risk factor for the recurrence of BPPV after successful repositioning procedures.[22] However, in this study, no significant differences were found in the number of repositioning procedures based on the presence of osteopenia or other densitometry findings. These results may be attributed to the fact that the majority of patients had osteopenia, as well as the small sample size. Additionally, the study period was two years, which may not have been long enough for any recurrences to occur.

In our study an association was observed between the presence of osteoporosis and BPPV, suggesting that osteoporosis may be a risk factor for the development of BPPV. The study could not establish the influence of low vitamin D or ionized calcium levels on the development of BPPV. Further research is needed to better understand these potential relationships.

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