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Original Article

Seasonal variations in serum levels of vitamin D and other biochemical markers among KSA patients prior to thyroid surgery

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الملخص

أهداف البحث: قد يختلف مستوى فيتامين (د) باختلاف فصول السنة مما قد يؤثر على مستوى الكالسيوم بين مرضى ما بعد استئصال الغدة الدرقية. كان الهدف من هذه الدراسة هو التحقيق في الاختلافات الموسمية في مستوى فيتامين (د) والتحاليل المخبرية الأخرى في المرضى ما قبل جراحة الغدة الدرقية في الرياض، المملكة العربية السعودية.

طرق البحث: تم تحليل ٦٨٥ مريضا خضعوا لجراحة الغدة الدرقية. تم تصنيف المرض حسب الشهر الذي أجريت فيه الجراحة إلى الأشهر الباردة (نوفمبر-فبراير) والأشهر الدافئة (مارس-أكتوبر).

النتائج: وجد أن لدى ٧٠٪ من المرضى نقص في مستوى فيتامين (د) وكان غير كاف لدى ١٨٪، ومثالي لدى ١٢٪، وكان متوسط عمر المرضى في المجموعة التي لديها نقص أقل بكثير مقارنة بالمجموعة المثالية. وكان هناك عدد أكبر بكثير من المرضى الذين يعانون من نقص فيتامين (د) خلال موسم البرد مقارنة بالموسم الدافئ. لم يختلف مستوى فيتامين (د) ومستوى الكالسيوم بين المواسم بشكل عام.

الاستنتاجات: تشير هذه الدراسة إلى أن التغير الموسمي لا يؤثر على مستوى الفيتامين (د)، بينما كانت مستويات المغنيسيوم والهرمون المنشط للغدة الدرقية قبل الجراحة أعلى بكثير خلال الموسم الدافئ / الحار مقارنة بالموسم البارد، مع عدم وجود اختلاف كبير في مستويات الكالسيوم في الدم للمرضى قبل العملية الجراحية. هناك العديد من العوامل الأخرى التي يجب أخذها في الاعتبار التي قد تسبب التباين في مستويات فيتامين (د) قبل الجراحة. هناك حاجة لدراسات مستقبلية لتأكيد هذا التباين.

الكلمات المفتاحية: الشرق الأوسط؛ التغير الموسمي؛ المملكة العربية السعودية؛ فيتامين د؛ استئصال الغدة الدرقية

Abstract

Objectives: Serum levels of vitamin D can vary between seasons, which may affect serum calcium levels in post-thyroidectomy patients. This study aimed to determine seasonal variations in serum levels of vitamin D and other biochemical markers in patients prior to thyroid surgery in a KSA hospital.

Methods: In this study, we analysed the data of 685 post-thyroidectomy patients. The preoperative laboratory values of all patients were collected, and the patients were categorized into groups based on the month when the surgical procedure was performed as follows: cold (November–February) and warm/hot groups (March–October).

Results: Serum vitamin D levels were deficient in 70% of the patients, insufficient in 18%, and optimal in 12%. The mean age of patients in the deficient group was significantly lower than that in the optimal group. There were significantly more patients who had vitamin D deficiency during the cold season than during the warm/hot season ($p = 0.024$). Serum vitamin D levels did not vary between seasons ($p = 0.836$); however, the preoperative magnesium and thyroid stimulating hormone (TSH) levels were significantly higher during the warm/hot season than during the cold season ($p = 0.039$ and

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$p < 0.001$, respectively). Preoperative calcium level was not significantly different between the cold and warm/hot months ($p = 0.282$).

Conclusion: This study suggests a non-significant seasonal fluctuation in serum levels of vitamin D with insignificant variation in serum calcium levels during cold and warm/hot seasons. The findings necessitate a careful review of the patients' biochemical status prior to surgery. Future prospective longitudinal studies are needed to confirm this variability.

Keywords: KSA; Middle East; Seasonal variation; Thyroidectomy; Vitamin D

Introduction

Vitamin D is a fat-soluble steroid vitamin that plays a key role in calcium homeostasis by increasing the intestinal absorption and metabolism of calcium, magnesium, and phosphorus.[1,2] The majority of vitamin D in the body is obtained through cutaneous synthesis (80%−100%), and the ability of the body to synthesise vitamin D depends on the amount of sunlight the skin receives.[3,4] The day length, which is the period between sunrise and sunset, varies with latitude and the time of the year. People living at the equator experience approximately 12 h of daytime throughout the year.[5] In contrast, people living at the Polar Circle latitudes of 66.33′, north or south, experience at least one day per year when the sun is above the horizon for 24 h, and at least one day per year when the sun is below the horizon for 24 h. During winter, exposure to natural sunlight diminishes with increasing latitude.[6]

Recently, there has been growing interest in the vitamin D levels of thyroid patients because of its impact on post-thyroidectomy hypocalcaemia and hypocalcaemia treatment. Several recent studies have recognised vitamin D deficiency as a risk factor for post-thyroidectomy hypocalcaemia and the importance of vitamin D status in directing post-thyroidectomy hypocalcaemia management.[7−11] This interest is driven by the impact of post-thyroidectomy hypocalcaemia on patients' postoperative quality of life, and by the financial burden imposed by hypocalcaemia on patients and the health care system[12,13]; it has been reported that the median hospital stay increases by 51.5 h if the patient develops hypocalcaemia, and the estimated cost of bed utilisation in a local hospital is $23US per hour.[12]

Because of seasonal variations in sunlight exposure, variations in vitamin D levels have been proposed to occur. However, the phenomenon of variation in vitamin D levels over the year remains controversial. Several studies have concluded that vitamin D levels fluctuate over the year,[14−17] whereas other studies have concluded the opposite.[18] Several factors might account for the inconsistency in the reported results regarding the prevalence of vitamin D deficiency. The most important of these factors is the lack of a standard definition of vitamin D deficiency based on a serum vitamin D cut-off value. Thus, to date, there is no clear consensus regarding acceptable seasonal variation in vitamin D levels.

Apart from the seasonal variation of vitamin D, several other factors also include higher levels of parathyroid hormone (PTH) in the cold when vitamin D levels are low causing an increase in bone resorption and fractures.[19−22] Serum calcium and phosphate were reported to decrease whereas alkaline phosphatase and PTH were reported to increase during the cold season, although some studies showed no significant seasonal variations in serum calcium and urinary excretion of calcium especially among hypercalciuria prone patients.[23,24] Reports also showed that vitamin D deficiency was correlated with magnesium deficiency.[25]

KSA is well known for receiving abundant sunlight all year long. Therefore, we hypothesised that a seasonal variation in vitamin D levels might not occur in Saudi Arabian residents since they are exposed to adequate sunlight. To test this hypothesis and to determine the prevalence of vitamin D deficiency in the Saudi population, we investigated seasonal variations in vitamin D levels and the correlation between vitamin D levels and other laboratory values in patients prior to thyroid surgery in Riyadh, KSA.

Materials and Methods

Study participants

The study protocol was approved by King Saud University Hospital Institutional Review Board (Research Project No. E-16-1813). The need for informed consent was waived owing to the retrospective design of this study. We reviewed the charts of all patients who underwent thyroid surgery between 2010 and 2015 at King Abdulaziz University Hospital (KAUH) and King Fahad Medical City (KFMC). Thyroid surgery includes total thyroidectomy, completion thyroidectomy, and hemithyroidectomy. Patient demographic data, including age, gender, and body mass index (BMI), were collected. Histopathology reports and laboratory levels of corrected calcium, vitamin D, parathyroid hormone, phosphorus, and magnesium were reviewed. The exclusion criteria were as follows: missing vitamin D level data, a history of vitamin D or calcium supplement use in the three months prior to surgery, and comorbidities affecting calcium and vitamin D levels, including renal and parathyroid disease. In KSA, the cold season typically start in November and continue until February. Based on the records available from 1980 to 2016, a report of the typical weather in Riyadh defined the winter season from the end of November until the end of February. Based on this report, we divided the year into cold season (November to February) and warm season (March to October).[26] Patients were classified based on the month in which the surgery was performed as the cold and warm/hot groups.

Biochemical tests

According to our protocol at KAUH and KFMC, all patients admitted for thyroid surgery undergo tests to determine the preoperative serum levels of the following: corrected calcium, vitamin D (25-hydroxyvitamin D), parathyroid hormone, phosphorus, and magnesium. Corrected calcium, phosphate, and magnesium levels were measured using an autoanalyzer, whereas 25-hydroxyvitamin D levels were measured using an immunoassay. We used the following normal laboratory reference values: corrected calcium 2.25–2.5 mmol/L, parathyroid hormone 1.6–6.9 pmol/L, phosphate 2.5–4.5 mg/dL, and magnesium 0.7–1 mmol/L, and we evaluated the vitamin D status in patients based on the Endocrine Society clinical practice guidelines. According to the guidelines, a vitamin D level <50 nmol/L is considered deficient, 50–74 nmol/L is considered insufficient, and ≥75 nmol/L is considered optimal.

Statistical analysis

Descriptive statistical data are presented as mean ± standard deviation (SD). An independent-samples t-test was used to compare the mean age between patients with deficient, insufficient, and optimal vitamin D levels. The Spearman correlation test was used to correlate vitamin D levels with other preoperative markers. The independent-samples t-test was used to compare vitamin D and PTH levels between the cold and warm season. The data were analysed using the Statistical Package for the Social Sciences version 16.0 (SPSS, Chicago, IL, USA). The significance level was set at $p < 0.05$.

Results

Subjects' characteristics

Of the 943 patients who underwent thyroidectomy, 258 were excluded. Of those excluded, 183 patients had missing vitamin D level, 7 had a history of hyperparathyroidism, and 68 had a history of vitamin D or calcium supplement use (22 patients were taking concomitant vitamin D and calcium supplements, 29 were taking vitamin D supplements alone, and 17 were taking calcium supplements alone). The remaining 685 were included in the analysis. The demographic characteristics are shown in Table 1. The mean (SD) patient age was 41 (14) years (with range from 9 to 90 years), and 548 (80%) patients were female. The mean (SD) height, weight, and BMI values were 1.59(0.09) m, 78.93(19.15) kg, and 30.93(7.09) kg/m^2, respectively. The final histopathology revealed benign lesions in 349 patients (50.9%) and malignant lesions in 336 patients (49.1%).

Preoperative biochemical parameters

The results of the preoperative laboratory tests are shown in Table 2. Vitamin D levels were deficient in 70% of patients, insufficient in 18%, and optimal in 12%. The mean (SD) age of patients in the deficient group was significantly lower than that of the optimal group (39.68 ± 13.37 years vs 46.67 ± 12.37 years, respectively; $p = 0.022$). Spearman's correlation coefficient analysis revealed a significant negative correlation between preoperative vitamin D and parathyroid hormone levels ($r = -0.115$, $p = .003$). In contrast, no significant correlation was found between preoperative vitamin D levels and preoperative levels of magnesium ($r = -0.003$, $p = 0.9$), phosphorus ($r = 0.052$, $p = 0.3$), and corrected calcium ($r = 0.065$, $p = 0.10$).

Table 1: Demographics of the patients in this study.

Variable	
Gender	n (%)
Male	137 (20%)
Female	548 (80%)
Age, mean ± SD (years)	41 ± 14
Age groups, n (%)	
≤20 years	29 (4.2%)
21–40 years	331 (48.3%)
41–60 years	256 (37.4%)
>60 years	69 (10.1%)
Height, mean ± SD (m)	1.59 ± 0.09
Weight, mean ± SD (kg)	78.93 ± 19.15
BMI, mean ± SD (m/kg^2)	30.93 ± 7.09

Table 2: Preoperative laboratory values of the patients.

Preoperative variables	Mean serum levels	Standard deviation	Range
Vitamin D (nmol/L)	39.89	27.07	7.0–203.0
Magnesium (mmol/L)	0.82	0.08	0.47–1.15
Phosphate (mg/dL)	1.10	0.19	0.61–1.73
Parathyroid hormone (pmol/L)	6.54	4.63	1–70
Corrected calcium (mmol/L)	2.30	0.12	2.0–2.98

Seasonal variations in biochemical parameters

Of the 685 patients, 225 (32.8%) underwent surgery in the cold season, and 460 (67.2%) underwent surgery in the warm seanon. Figure 1 shows the distribution of patients across the vitamin D categories for every month of the year. The independent-samples t-test revealed no significant differences in the levels of vitamin D (39.61 ± 23.89 nmol/L vs.

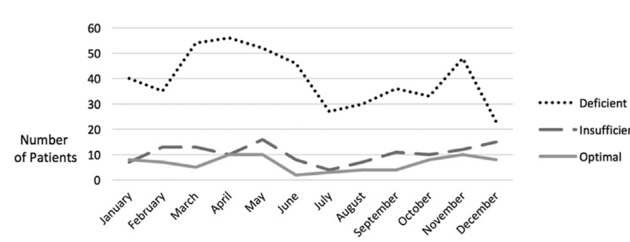

Figure 1: Distribution of the included patients across the vitamin D categories for every month of the year.

Table 3: Comparison of the biochemical parameters between warm/hot season and cold season.

Parameters	Warm/hot season N = 225	Cold season N = 460	P value
Vitamin D deficiency, n (%)	145 (64.4%)	335 (72.8%)	0.024
Vitamin D level,	40.03 ± 25.66	39.61 ± 23.89	0.836
Pre-op PTH	6.65 ± 4.19	6.49 ± 4.83	0.668
Pre-op Mg,	0.84 ± 0.08	0.81 ± 0.08	0.039
Pre-op PO_4	1.11 ± 0.19	1.09 ± 0.19	0.565
Pre-op corrected Ca	2.31 ± 0.12	2.30 ± 0.11	0.282
Pre-op TSH	4.34 ± 2.86	2.25 ± 2.65	<0.001
Tumour size	2.36 ± 1.98	2.03 ± 1.82	0.155

Pre-op PTH, preoperative parathyroid hormone; Pre-op Mg, preoperative magnesium level; Pre-op PO4, preoperative phosphate level; Pre-op corrected Ca, preoperative corrected calcium; Pre-op TSH, preoperative thyroid stimulating hormone.

40.03 ± 25.66 nmol/L, $p = 0.836$) or parathyroid hormone (6.49 ± 4.83 pmol/L vs. 6.65 ± 4.19 pmol/L, $p = .668$) between patients who underwent surgery in the warm and cold seasons.

There were significantly more patients with vitamin D deficiency during the cold season than during warm/hot season (n = 335, 72.8% versus n = 145, 64.4%, $p = 0.024$). The preoperative Mg level was also significantly higher during the warm/hot season than during the cold season (0.84 ± 0.08 versus 0.81 ± 0.08, $p = 0.039$). The preoperative TSH level was also significantly higher in the warm/hot season than in the cold season (4.34 ± 2.86 versus 2.25 ± 2.65, $p < 0.001$). Preoperative calcium was not significantly different between the cold and warm/hot seasons ($p = 0.282$). There were no other significant differences in biochemical parameters between the warm/hot and cold seasons (Table 3).

There were significant correlations between vitamin D deficiency and the investigated parameters. Vitamin D deficiency was significantly correlated with the male gender ($r = -0.088$, $p = 0.022$), increased PTH levels ($r = 0.171$, $p = 0.037$), decreased preoperative calcium level, ($r = -0.099$, $p = 0.015$), larger tumour size ($r = 0.121$, $p = 0.032$), and heavier thyroid weight ($r = 0.128$, $p = 0.004$). No significant correlations were found between vitamin D deficiency and magnesium ($r = -0.009$, $p = 0.879$), TSH ($r = -0.044$, $p = 0.265$), and phosphate ($r = -0.068$, $p = 0.251$).

Discussion

In this study, we found no significant seasonal variation in the vitamin D levels detected in the study population of prethyroidectomy patients. In contrast, we found a high prevalence of vitamin D deficiency; further, the mean age of patients in the deficient group was significantly lower than that of patients in the optimal group. A significant negative correlation between preoperative vitamin D level and parathyroid hormone level was found; however, that significant correlation was not present when correlated with other preoperative laboratory values.

An important finding in our study was the high prevalence of vitamin D deficiency (70%). Despite campaigns in KSA to raise awareness, the incidence of vitamin D deficiency continue to show an upward trend. Compared to other local reports, our findings show that the prevalence of vitamin D deficiency in patients with thyroid dysfunction is higher than that in the general population of KSA.[27–29] In a study that included 3475 patients, Alfawaz et al. reported a similar prevalence of vitamin D deficiency: 78.1% in women and 72.4% in men.[27] A randomised study with similar cut-off values conducted on healthy individuals who were accompanying patients to primary healthcare centres in Al-Qaseem province found the prevalence of vitamin D deficiency, insufficiency, and optimal levels to be 28.3%, 39.4%, and 32.2%, respectively.[28] Another study with similar cut-off values performed in Eastern KSA on randomly selected healthy individuals found the prevalence of vitamin D deficiency to be 10% in young individuals and 12% in adults.[29] A likely explanation for this prominent dissimilarity in the prevalence of vitamin D deficiency among studies conducted in different regions of the country could be selection bias. It is well known that Al-Qaseem is an agricultural province, and its inhabitants stay outdoors relatively longer than those in the other regions of the country. Moreover, because of their location on the seacoast, Eastern province residents rely heavily on vitamin D rich fish as a source of food, compared to residents of the Riyadh metropolitan area.

Although most studies have revealed a higher prevalence of vitamin D deficiency in the older population, we found that the mean age of patients who were deficient in vitamin D was significantly lower than the mean age of those with optimal levels. This finding could be explained by the fact that in Saudi Arabian culture, older people generally have healthier lifestyle habits than the younger generation, including spending more time outdoors and eating healthier food. A higher prevalence of vitamin D deficiency in younger people has also been identified in other studies conducted in non-Saudi populations.[30,31]

Because both vitamin D and PTH are calciotropic hormones that play an important role in calcium metabolism, vitamin D deficient patients become more dependent on PTH.[32] It has been documented that a 25-hydroxyvitamin D level ≥40 nmol/L is associated with a low PTH level.[33] Consistent with this relationship, the mean PTH level of our patients was in the upper normal range, and the mean vitamin D level was below 40 nmol/L. Moreover, our data showed a linear drop in vitamin D level associated with a rising PTH level. This inverse relationship between preoperative PTH and vitamin D levels further confirms the prevalent vitamin D deficiency in our study participants. Furthermore, our data showed no relationship between preoperative vitamin D levels and other preoperative laboratory values, including magnesium, corrected calcium, and phosphate.[32,33]

Geographical areas located at latitudes closer to the equator are known to have daylight for approximately 12 h per day throughout the year[5]; therefore, people residing in these areas are typically exposed to enough sunlight in both summer and winter to continue vitamin D production year-round.[34] In contrast, people living closer to the poles, where daylight hours vary markedly between seasons, experience greater seasonal variations in exposure to sunlight that negatively impact the production of vitamin D via the skin during winter.[35] For instance, individuals living at latitudes greater than 33° north or south have been reported to produce little or no vitamin D during the winter season.[4] A study on thyroid patients conducted in Beppu, Japan (located at 33.2846° N) revealed significant seasonal variations in the vitamin D levels of patients pre-thyroidectomy.[14] Studies performed in northern latitudes (Evanston, USA (located at 42.0451° N)[15] and Reykjavik, Iceland (located at 64.1265°N)) and southern latitudes (Launceston, Australia (located at 41.4332°S)) reported similar findings.[16,17]

However, the findings of this study support our original hypothesis that seasonal variations in vitamin D levels do not occur in Riyadh, KSA (located at 24.7136° N). One probable explanation is that the weather and daylight hours in Riyadh, KSA are less variable compared to the other parts of the world. Saudi patients who underwent thyroid surgery in the warm season had levels of preoperative vitamin D comparable to those who underwent surgery during the cold season. However, despite the absence of a seasonal variation in vitamin D levels, we found a significantly larger number of patients with vitamin D deficiency during the cold season.

This led us to ask, "Why is there a larger proportion of vitamin D deficient individuals in a non-significant, non-seasonal variation or fluctuation of vitamin D levels?" There are several possible explanations. Many studies have established the seasonal association and fluctuation of vitamin D levels and vitamin D deficiency.[19,20] However, other factors including magnesium, phosphate, calcium, and TSH levels, which may have been inherently abnormal, may have affected the vitamin D levels in these patients. Higher magnesium and TSH levels during the warm/hot season were reported to be directly associated with a higher level of vitamin D, and a decrease in magnesium and TSH levels during cold season may cause bone resorption and fractures as numerous studies have reported.[19–22] However, we did not find any significant seasonal variation in the calcium level, though calcium levels were significantly associated with vitamin D deficiency. This study has also concurred with previous studies that calcium and phosphate had no significant seasonal variation as opposed to magnesium, PTH, and vitamin D levels.[23,24] One probable reason why vitamin D deficiency does not generally cause malabsorption of calcium is that serum 1,25-dihydroxyvitamin D, which is the major determinant of calcium absorption, is maintained by secondary hyperparathyroidism until the serum $1,25(OH)_2D$ falls to approximately 10 nM as suggested by Need et al. (2008).[36] There could also be other factors that need to be investigated as to why these patients had vitamin D deficiency despite the non-seasonal variation of vitamin D levels.

This study has some limitations. First, we used a non-randomised sample which only included patients with thyroid dysfunction who visited our hospitals, and not the general population. Second, the higher number of patients who underwent surgery during the summer season compared to the winter season, and the exclusion of patients with missing vitamin D level data (19%), might have influenced our results. Our exclusion of patients who were on vitamin D supplementation and those who were taking calcium medications might have also affected the results.

Conclusion

This study found a non-significant seasonal fluctuation in vitamin D levels with no significant variation in serum calcium levels during the cold and warm/hot seasons, indicating the need for a careful review of the biochemical status of patients prior to surgery. Many other inherent factors should be considered that may cause variability in vitamin D levels prior to surgery. Future prospective longitudinal studies are needed to confirm this variability. Moreover, although daylight hours in KSA are long throughout the year, vitamin D deficiency is still prevalent. In Saudi patients, we suggest routine preoperative screening for vitamin D deficiency and correction of vitamin D levels accordingly.

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Conflict of interest

The authors have no conflicts of interest to declare.

Ethical approval

This manuscript has been approved by King Saud University Research Center (Project No. E-16-1813), 25 February, 2016. The support was non-financial, its logistic support such as consultation, provide the necessary programs such spss, endnote etc.

Authors contributions

TA conceived and designed the study, and assisted in drafting the manuscript; SA assisted in drafting the manuscript, conducted the research, and collected and organised the data; AA assisted in drafting the manuscript; SA designed the study and collected and organised the data; SD analysed and interpreted the data and provided logistic support and supervision. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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References

1. Hardwick LL, Jones MR, Brautbar N, Lee DB. Magnesium absorption: mechanisms and the influence of vitamin D, calcium and phosphate. **J Nutr 1991**; 121: 13–23.

2. Harkness L, Cromer B. Low levels of 25-hydroxy vitamin D are associated with elevated parathyroid hormone in healthy adolescent females. **Osteoporos Int 2005**; 16: 109—113.
3. Kimlin MG. Geographic location and vitamin D synthesis. **Mol Aspect Med 2008**; 29: 453—461.
4. Wacker M, Holick MF. Sunlight and Vitamin D: a global perspective for health. **Dermato-endocrinol 2013**; 5: 51—108.
5. Clegg J. *Elements of geography, or an easy introduction to the use of the globes and maps; consisting of a concise Treatise...a blank atlas, and a large collection of geographical Questions...with the answers printed separately*. Farmington Hills, MI: Gale ECCO; 2010.
6. ArendtJ. Biological rhythms during residence in polar regions. **Chronobiol Int 2012**; 29: 379—394.
7. Kirkby-Bott J, Markogiannakis H, Skandarajah A, Cowan M, Fleming B, Palazzo F. Preoperative vitamin D deficiency predicts postoperative hypocalcemia after total thyroidectomy. **World J Surg 2011**; 35: 324—330.
8. Erbil Y, Bozbora A, Ozbey N. Predictive value of age and serum parathormone and vitamin D3 levels for postoperative hypocalcemia after total thyroidectomy for nontoxic multinodular goiter. **Arch Surg 2007**; 142: 1182—1187.
9. Al-Khatib T, Althubaiti AM, Althubaiti A, Mosli HH, Alwasiah RO, Badawood LM. Severe vitamin D deficiency A significant predictor of early hypocalcemia after total thyroidectomy. **Otolaryngol Head Neck Surg 2014**; 152: 424—431.
10. Al-Dhahri SF, Mubasher M, Al-Muhawas F, Alessa M, Terkawi RS, Terkawi AS. Early prediction of oral calcium and vitamin D requirements in post-thyroidectomy hypocalcaemia. **Otolaryngol Head Neck Surg 2014**; 151: 407—414.
11. Tripathi M, Karwasra RK, Parshad S. Effect of preoperative vitamin D deficiency on postoperative hypocalcemia after thyroid surgery. **Thyroid Res 2014**; 7: 8.
12. Fahad Al-Dhahri S, Al-Ghonaim YA, Sulieman Terkawi A. Accuracy of postthyroidectomy parathyroid hormone and corrected calcium levels as early predictors of clinical hypocalcemia. **J Otolaryngol Head Neck Surg 2010**; 39: 342—348.
13. Tolone S, Roberto R, del Genio G. The impact of age and oral calcium and vitamin D supplements on postoperative hypocalcemia after total thyroidectomy. A prospective study. **BMC Surg 2013**; 13(Suppl 2): S11.
14. Yamashita H, Noguchi S, Murakami T, Watanabe S, Uchino S, Ohshima A, et al. Seasonal changes in calcium homeostasis affect the incidence of postoperative tetany in patients with Graves' disease. **Surgery 2000**; 127: 377—382.
15. Rosecrans R, Dohnal JC. Seasonal vitamin D changes and the impact on health risk assessment. **Clin Biochem 2014**; 47: 670—672.
16. Steingrimsdottir L, Gunnarsson O, Indridason OS, Franzson L, Sigurdsson G. Relationship between serum parathyroid hormone levels, vitamin D sufficiency, and calcium intake. **J Am Med Assoc 2005**; 294: 2336—2341.
17. Bird ML, Hill KD, Robertson I, Ball MJ, Pittaway JK, Williams AD. The association between seasonal variation in vitamin D, postural sway, and falls risk: an observational cohort study. **J Aging Res 2013**; 2013: 751310.
18. Laney N, Meza J, Lyden E, Erickson J, Treude K, Goldner W. The prevalence of vitamin D deficiency is similar between thyroid nodule and thyroid cancer patients. **Int J Endocrinol 2010**; 2010: 805716.
19. Pasco JA, Henry MJ, Kotowicz MA, Sanders KM, Seeman E, Pasco JR, et al. Seasonal periodicity of serum vitamin D and parathyroid hormone, bone resorption, and fractures: the Geelong Osteoporosis Study. **J Bone Miner Res 2004 May**; 19(5): 752—758.
20. Itoh H, Mori I, Matsumoto Y, Maki S, Ogawa Y. Vitamin D deficiency and seasonal and inter-day variation in circulating 25-hydroxyvitamin D and parathyroid hormone levels in indoor daytime workers: a longitudinal study. **Ind Health 2011**: 1106170071.
21. Kroll MH, Bi C, Garber CC, Kaufman HW, Liu D, Caston-Balderrama A, Suffin SC, et al. Temporal relationship between vitamin D status and parathyroid hormone in the United States. **PloS One 2015 Mar 4**; 10(3):e0118108.
22. Christensen MH, Lien EA, Hustad S, Almås B. Seasonal and age-related differences in serum 25-hydroxyvitamin D, 1, 25-dihydroxyvitamin D and parathyroid hormone in patients from Western Norway. **Scand J Clin Lab Investig 2010 Jul 1**; 70(4): 281—286.
23. Bouillon RA, Auwerx JH, Lissens WD, Pelemans WK. Vitamin D status in the elderly: seasonal substrate deficiency causes 1, 25-dihydroxycholecalciferol deficiency. **Am J Clin Nutr 1987 Apr 1**; 45(4): 755—763.
24. Hilgenfeld MS, Simon S, Blowey D, Richmond W, Alon US. Lack of seasonal variations in urinary calcium/creatinine ratio in school-age children. **Pediatr Nephrol 2004 Oct 1**; 19(10): 1153—1155.
25. Woodward G, Wan JC, Viswanath K, Zaman R. Serum Vitamin D and Magnesium levels in a psychiatric cohort. **Psychiatr Danub 2019 Sep**; 31(3): 221—226.
26. Weather Spark. *Average weather in Riyadh Saudi Arabia*; June 20 2017 https://weatherspark.com/y/104018/Average-Weather-in-Riyadh-Saudi-Arabia-Year-Round.
27. Alfawaz H, Tamim H, Alharbi S, Aljaser S, Tamimi W. Vitamin D status among patients visiting a tertiary care center in Riyadh, Saudi Arabia: a retrospective review of 3475 cases. **BMC Publ Health 2014**; 14: 159.
28. Naeem Z, Almohaimeed A, Sharaf FK, Ismail H, Shaukat F, Inam SB. Vitamin D status among population of Qassim region, Saudi Arabia. **Int J Health Sci 2011**; 5: 116—124.
29. Sadat-Ali M, AlElq A, Al-Turki H, Al-Ali A. Vitamin D levels in healthy men in eastern Saudi Arabia. **Ann Saudi Med 2009**; 29: 378—382.
30. Orell—Kotikangas H, Schwab U, Osterlund P, Saarilahti K, Makitie O, Makitie AA. High prevalence of vitamin D insufficiency in patients with head and neck cancer at diagnosis. **Head Neck 2012**; 34: 1450—1455.
31. Hovsepian S, Amini M, Aminorroaya A, Amini P, Iraj B. Prevalence of vitamin D deficiency among adult population of Isfahan City, Iran. **J Health Popul Nutr 2011**; 29: 149—155.
32. Kirkby-Bott J, Markoqiannakis H, Skandarjah A, Cowan M, Fleming B, Palazzo F. Preoperative vitamin D deficiency predicts postoperative hypocalcemia after total thyroidectomy. **World J Surg 2011**; 35: 324—330.
33. Outila TA, Karkkainen MU, Lamberg-Allardt CJ. Vitamin D status affects serum parathyroid hormone concentrations during winter in female adolescents: associations with forearm bone mineral density. **Am J Clin Nutr 2001**; 74: 206—210.
34. Mithal A, Wahl DA. Bonjour JP Global vitamin D status and determinants of hypovitaminosis D. **Osteoporosis Int 2009**; 20: 1807—1820.
35. Webb AR, Kline L, Holick MF. Influence of season and latitude on the cutaneous synthesis of vitamin D3: exposure to

winter sunlight in Boston and Edmonton will not promote vitamin D3 synthesis in human skin. **J Clin Endocrinol Metab 1988**; 67: 373–378.
36. Need AG, O'Loughlin PD, Morris HA, Coates PS, Horowitz M, Nordin BC. Vitamin D metabolites and calcium absorption in severe vitamin D deficiency. **J Bone Miner Res 2008 Nov**; 23(11): 1859–1863.

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