Obesity and Bariatric Surgery: Ultimate Need for Vitamin D Supplementation

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Abstract

Obesity and morbid obesity comprise mounting serious health problems reaching epidemic ratios in many countries. The cause of low levels of serum 25-hydroxyvitamin D in obese individuals remains obscure although increasing number of the postulations including vitamin D sequestration in fat tissues, rendering it less bioavailable for transformation into calcitriol, and diminished sun exposure. Bariatric surgery is one of the most efficacious long-term weight reduction procedures. Patients who are submitted to bariatric surgery are at increased risk of vitamin D insufficiency (VDI) and deficiency (VDD) that are potentially correlated with skeletal and non-skeletal pathology. Nevertheless, there is no assent considering the favorable management for these events. The severity of vitamin D deficiency due to bariatric surgery is obviously linked to the modality of bariatric procedures implemented, weight loss rate, and the intensity of malabsorption of other micro- and macro-nutrients. According to the Clinical Practice Guidelines (CPGs) on vitamin D supplementation in bariatric surgery, high doses of vitamin D supplementations, ranging from 3,000 IU daily to 50,000 IU 1 – 3 times weekly are strongly recommended. Nevertheless, they do not fulfill criteria for applicability. Patients programmed for bariatric surgery should

be motivated to follow continuous physical activity, appropriate dietary habits, and vitamin D supplementations pre- and post-operatively.

Keywords

Adipokines Bariatric surgery; Obesity; Vitamin D; 25-hydroxyvitamin D;

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Introduction

The rate of obesity had multiplied over the last 3 decades in most countries[1] reaching alarming epidemic rates in many countries.[2] Strikingly, the prevalence of obesity reached more or less 15.5 % in the European adult population and Italian adults have the lowest prevalence estimated at 9 %.[3] Overweight and obesity influenced more than 75% of the total population in Saudi Arabia and most of age groups are generally affected especially adults.[4]

Obesity is a challenging health problem [5] as morbid obesity was found to be linked with diminished functional capacity, multiple comorbidities, and higher mortality rates.[6] When patients with morbid obesity (BMI ≥40 kg/m ^{2}) are not able to lose weight using classic strategies of weight reduction, it is sense that bariatric surgery be deemed.[7]

As the employment of bariatric surgery to manage morbid obesity in adults keeps rising, surgeons should be mindful of dietary insufficiencies in patients submitted for bariatric surgery and these insufficiencies should be early disclosed to eschew post-operative bariatric adverse events. Hence, it is highly recommended to screen nutritional deficiency and prescribe enough supplementations to avoid nutrients' shortage following bariatric operations employing sleeve gastrectomy and Roux-en Y gastric bypass.[8] Vitamin D deficiency is common following bariatric surgery and has been reported to occur in 50-80% of bariatric patients.[7]

Obesity and Vitamin D Deficiency

Obesity and morbid obesity comprise mounting serious health problems reaching epidemic ratios in most countries. Relationships and interactions between obesity and bone tissue and its metabolism are sophisticated but are extensively studied. Obesity is correlated with alterations of some hormones including particularly bone-regulating hormones like vitamin D. Bariatric surgery procedures are effectively appreciated for their growing success to achieve therapeutic endpoints for comorbidities-related obesity. However, these surgical procedures by carrying out malabsorption syndrome and/or mechanical restriction result in nutritional insufficiencies of micronutrients including vitamin D.[9]

Durá-Travé *et al* reported that female, pubertal age, autumn, winter and spring time, urban residence and severe obesity were found to be independent predictors for hypovitaminosis D in obese Spanish children[10] whereas, Wakayo *et al* reported that deficiency of vitamin D is an significant independent prognosticator that related to adiposity among Ethiopian schoolchildren.[11]

Vitamin D deficiency and obesity pandemic upholds the role for Vitamin D in occurrence and prevention of obesity.[12] There are many justifying theories explain this issue. Although the explication for the high risk of vitamin D deficiency in obesity is not well known, it has been suggested that obese subjects due to sedentary life style may avert sun light exposure, which is substantial for the cutaneous biosynthesis of calcitriol.[13] So, it is not surprising that people who are existing in less sunlit northern states of America may experience calcitriol deficiency as sun exposure is crucial in the synthesis of vitamin D.[14] Moreover, it has also been supposed that the catabolism of vitamin D may rise in obese individuals, perhaps due to promoted uptake by adipocytes.[15]

Diminished bioavailability of cholecalciferol from skin and nutritional sources expounds obesity-linked vitamin D insufficiency. The reason for this is its precipitation in body adipocytes. This is proven by Wortsman *et al* who conducted their study on obese (BMI $\geq$ 30) and matched normal-weight control individuals (BMI $\leq$ 25) receiving either an oral supplementation of vitamin D_2 or whole-body ultraviolet irradiation to assess whether obesity modifies the intestinal absorption of ergocalciferol or skin biosynthesis of cholecalciferol. They concluded that individuals suffering from obesity had significantly more parathyroid hormone (PTH) levels and less basal 25-hydroxyvitamin D levels when compared with control subjects. After 24 h whole-body irradiation, assessment of blood vitamin D_3 levels revealed a 57% decrease in the progressive elevation of vitamin D_3 in obese compared with non-obese individuals in spite of insignificant alterations in cutaneous 7-dehydrocholesterol obese and non-obese individuals.[16]

Obesity had been uniquely correlated with varying concentrations of certain hormones and bone minerals, particularly parathyroid hormone and 25-hydroxyvitamin D in addition to variations with race and age.[17]

In a multiple regression analytic study, the weight was the main determinant of elevated levels of serum parathyroid hormone and the increase in serum parathyroid hormone was due to weight increase in and not due to blood concentrations of 25-hydroxyvitamin D.[18]

Thus, the cause of low levels of serum 25-hydroxyvitamin D in obese individuals remains obscure although increasing number of the pre-mentioned postulations including vitamin D sequestration in fat tissues, rendering it less bioavailable for transformation into calcitriol[16,19] and diminished sun exposure.[20]

A more recent study proposed that the low vitamin D status of obesity could be artlessly the result of the volumetric dilution of cutaneously synthesized or ingested vitamin D3 in the large fat mass of obese patients.[21]

Role of Cytokines and Adipokines in Low Vitamin D Related Obesity

There is increasing awareness for vitamin D contribution in modulation of immune reactions.[22] The synthesis and release of proinflammatory adipocyte-derived proteins are influenced by body fat mass in parallel with vitamin D status. Deficiency of vitamin D was found to be positively correlated with serum concentrations of some inflammatory adipokines, like TNFα, C-reactive protein and IL-6 in obese subjects.[23,24]

Adiposity is renowned as a low-grade long-lasting systemic inflammatory state due to production of proinflammatory adipokines and adipose tissue macrophage infiltration.[25]

Accretion of local inflammation of adipocytes is associated with modulations in pathophysiology of adiposity-related adverse effects.[26,27] Thence, a realization of the molecular mechanisms beyond adipocytes alterations during the adiposity progression is mandatory for management of adiposity -related adverse events.[25]

Chang and Kim explored the impact of vitamin D on obesity in male rats after induction of adipose tissue inflammation. They divided rats into 3 groups, the first group (NOR) fed a normal diet with 1000 IU vitamin D/kg diet for 12 weeks, the second group (HF) fed a 45% high-fat diet with 1000 IU vitamin D/kg diet, while the third one (HF+LVD) fed a 45% high-fat diet with low vitamin D (25 IU /kg diet). Low vitamin D diet resulted in vitamin D inadequacy in the third group (HF+LVD) as indicated by low serum 25-hydroxy cholecalciferol concentration of 68.56 ± 7.97 nmol/L. High fat and low vitamin D exacerbated adipocyte bulk elevation, adipogenic gene expression of Peroxisome proliferator-activated receptor gamma (PPARγ), adipose tissue macrophage induction, and proinflammatory cytokines TNFα and IL-6 concentrations in epididymal white adipose tissue. In addition, a significant diminution in sirtulin 1 (SIRT1) and adenosine monophosphate-activated protein kinase activity were noted in (HF+LVD) group. The observed unwholesome impacts of vitamin D deficiency on increased adipocytes bulk, inflammatory status and immune cell infiltration propose vitamin D plays an advantageous role in metabolic events of adipose tissue and progression of adiposity. sirtulin 1 and adenosine monophosphate-activated protein kinase activity could play a significant role in the effectiveness of vitamin D.[25]

Strikingly, adipose tissue plays an substantial role in body homeostasis by production and secretion of many bioactive proteins the so-called adipokines like visfatin, adiponectin, leptin, resistin, and apelin, which are implicated in food intake control, lipid and glucose metabolism and insulin action.[28]

In obesity, blood flow imbalance-dependent adipocytes enlargement results in some events like hypoxia, inflammation, and macrophage infiltration.[29] The increase in the secretion of resistin, TNF-α, IL-6, IL-8 and monocyte chemoattractant (well-recognized proinflammatory cytokines) is one of the noteworthy traits in reduced secretion of adiponectin and adipocytes hypertrophy.[30] Vitamin D impact on the adaptive immune system can be detected through mitogen-activated protein kinase (MAPK), T helper cell differentiation, as well as a nuclear factor-kB (NF-kB).[31] Thence, vitamin D restrains autoimmune disease pathology by controlling the activity and differentiation of CD4Þ T cells, leading to a more balanced TH1/TH2 response favoring less emergence of autoimmunity.[32]

Thus, vitamin D is most likely to have an anti-adipogenic efficacy and may exert anti-inflammatory and immunoregulatory effects.[33]

Due to their role in obesity, adipokines' correlation with vitamin D was broadly studied. In vitro secretion of leptin was found to be potentially inhibited by deficiency of vitamin D [34]. Concordantly, other clinical trials revealed that Vitamin D supplementation caused an elevation in serum leptin.[35,36] In addition, visfatin, a new adipokine that plays an important role in inflammatory processes, has been recently found to be correlated with Vitamin D levels.[37]

Some researchers concluded that Vitamin D supplementation may display advantageous effects in minimizing inflammation and visfatin levels.[38] Reyman *et al* showed in their cross-sectional study that deficiency of 25-hydroxy cholecalciferol in obese children is linked with diminished insulin sensitivity and with enhanced systemic inflammation. The high cathepsin S and soluble vascular adhesion molecule concentrations may speculate promotion of atherogenic and proinflammatory pathways, which could be suppressed by supplementation of vitamin D.[39]

Bariatric Procedures Lead to Vitamin D Deficiency

A growing success had been achieved by bariatric surgery. However, these surgical procedures by making mechanical restriction and or malabsorption syndrome lead to nutritional deficiencies encompassing vitamin D.[40] Bariatric surgery is one of the most efficacious long-term weight reduction procedures [41] that increases over time with almost half of all patients are women of reproductive age.[42] Roux-en-Y gastric bypass (RYGB) and vertical sleeve gastrectomy (VSG) are the most common surgical procedures. Patients who are submitted to bariatric surgery are at increased risk of vitamin D insufficiency (VDI) and deficiency (VDD) that are potentially correlated with skeletal and non-skeletal pathology. Nevertheless, there is no assent considering the favorable management for these events.[41]

In spite of the assumptive health advantages, bariatric procedures entail not only an inclusive preoperative assessment but a guarantee from the patient to be committed to long-lasting follow-up as well. Postoperative follow up cares about maintenance of weight reduction and commitment to testaments with regard to micronutrient supplementation including vitamin D.[43] Hence, for maximal surgical outcome, patients should be motivated to restrict to continuous physical activity, appropriate dietary habits and vitamin D supplementations, cessation of smoking.[44]

Although, presurgical preparations targeting physical activity among obese subjects awaiting bariatric surgery is plausible and has the potency to boost patient’s adherence to physical activity postoperatively,[45] failure of bariatric surgery, measured by the inconvenient weight loss or the return of lost weight, remains possible and varies by bariatric procedure and follow-up intensity, ranging between 5 and 10% with higher rates in gastric banding.[46]

It is well recognized that the most likely long-term adverse events after bariatric surgery are micronutrient deficiencies and bariatric procedures can lead to expected wide-spread symptoms more badly than pre-existing ones.[47] For instance, some reports adduced that preoperative basal serum levels of vitamin D were significantly higher than that found after the Roux-en-Y gastric bypass with a 25% peak reduction.[48]

Elevated PTH and vitamin D deficiency are common adverse events following gastric bypass and proceed with time. Short-limb gastric bypass patients are prone to hyperparathyroidism, even in those with vitamin D levels ≥30 ng/mL, proposing Ca^{2+} malabsorption that require long term calcium and vitamin D supplementations.[49] Hence, serum 25-hydroxy vitamin D and calcium levels have to be continuously estimated after sleeve gastrectomy and gastric bypass.[50]

Low serum level of 25-hydroxy vitamin D had been recognized as an undesirable lineamen weight reduction surgery, but now findings of Peterson *et al* study added to knowledge that seasonal variation plays a fundamental role in how patients have to do after bariatric surgery. In the study, researchers reviewed 930,000 bariatric operations' records in the United States between 2001 and 2010. One of the most common finding was staying a few extra days in the hospital indicating the significant link between both geographical location and season.[51]

There is no assent on the optimal supplementation dose of vitamin D in post-bariatric surgical patients. So, it is substantial to realize and treat vitamin D deficiency before bariatric surgery so as to avoid postoperative adverse events, such as metabolic bone disease that associated with high risk of fractures[52] and ramifications of vitamin D deficiency in the post-bariatric individuals in the critical care setting with regard to the potential role of vitamin D in inflammation and immunity.[53] Thence, alternative regimes for managing vitamin D deficiency are strongly recommended in obese patients, particularly those in whom bariatric surgery is programmed.[54]

Currently, it has been realized that 25-hydroxy vitamin D level of ≥ 30 ng/mL is optimally healthy, even in those who have not had gastric bypass[55,56] to avoid vitamin D deficiency adverse effects.[54]

Some recent study reported that diminished food intake raises the risk of vitamin D deficiency after bariatric procedures and daily intake of 1,500 mg calcium citrate and 2,000 IU of vitamin D3 significantly raised 25-hydroxy vitamin D levels and minimized the proportion of vitamin D deficiency in women. Nevertheless, serum 25(OH)D levels did not reach levels linked with deleterious health events and m uch higher vitamin D supplementation may be necessary in those remained vitamin D deficient.[50]

Malabsorptive surgical procedures act primarily by waiving fat and fat-soluble vitamins absorption. Most studies of vitamin D status in bariatric surgery patients declared that over 50% of them experience vitamin D deficiency with serum level of <50 nmol/L, reaching 65% in one sturdy report. Chronicity of inflammation due to vitamin D deficiency in obese subjects may add an extraordinary risk of surgical complications like infections and poor wound healing due to re-epithelialization and immunological role of vitamin D. Addition of vitamin D deficiency to surgical complications make it more worse for patients. Moreover, vitamin D insufficiency is regarded as a metabolic adverse event of bariatric surgery. Consequently, adjustment of vitamin D status may demonstrate advantageous role before surgery.[57]

Petrson *et al* found that preoperative vitamin D deficiency (<20 ng/mL) ranged from 13% to 90%, while vitamin D insufficiency (<30 ng/mL) was found in up to 98% of patients. Prevalence kept unchanged after surgical intervention and RYGB had the highest one. They concluded that that blood levels of vitamin D above 30 ng/mL are optimally healthy and post-bariatric supplementation of vitamin D failed to increase 25-hydroxy vitamin D above the universal level.[41]

Similarly, Chakhtoura *et al* specified about 51 competent observational studies appreciating vitamin D status before and after bariatric surgery. 29 studies showed a pre-surgical mean level of 25(OH)D < 30 ng/ml, and ≤ 20ng/ml in 17 studies. Most of 25(OH)D concentrations persisted < 30 ng/ml after bariatric surgery, inspite of vitamin D supplementation. The increase in post-operative 25(OH)D levels varied widely across studies and tended to match increments in vitamin D supplementation dose. A 9-13ng/ml elevation in 25(OH)D concentration was accomplished when 25(OH)D deficiency was rectified by 1100-7100IU/day vitamin D supplementation doses, added to the daily maintenance dose of 400-2000IU. Thus, despite various vitamin D supplementation regimens, hypovitaminosis D persisted in obese patients who submitted for bariatric surgery.[58] Inconsistently, Magouliotis and co-researchers pointed in their meta-analysis to significant amelioration of postoperative levels of glucose, insulin, triglycerides, total cholesterol, LDL and HDL.[59]

Regardless of the bariatric procedure, vitamin D treatment and dosing surveys revealed variation in individuals’ response towards’ supplementation regimens.[53] Recommendations of Current Clinical Practice Guidelines (CPGs) on vitamin D supplementation in bariatric surgery differ between societies. They do not fulfill criteria for optimal guideline development, in part possibly due to limited resources, and are based on expert opinion.

Thus, the imperious need for high quality randomized trials to apprise CPGs, to be developed based on recommended standards.[60]

According to the 2013 American Society for Metabolic and Bariatric Surgery guidelines, physicians should bring blood concentrations to greater than 30 ng/mL of 25-hydroxyvitamin D. The society recommends achieving these readings by delivering the standard daily dose of at least 3,000 IU, test the patient's blood, adjust the dose, test again and repeat until the patient's vitamin D readings are optimized.[61]

The American Association of Clinical Endocrinologists (AACE), the Obesity Society (TOS), and the American Society for Metabolic & Bariatric Surgery (ASMBS) guidelines as well as Endocrine Society guidelines recommended high doses of vitamin D, ranging from 3,000 IU daily to 50,000 IU 1 – 3 times weekly. Nevertheless, the recommendations of these Clinical Practice Guidelines (CPGs) on vitamin D supplementation in bariatric surgery do not fulfill criteria for applicably optimal guideline.[62] Hence, Gold-standard tools for the quantification of vitamin D metabolites and expounding of studies' conclusions needs to be commenced within the context of alterations to serum 25-hydroxyvitamin D levels between baseline and post-supplementation rather than patient compliance to tailor daily dosage regimen accordingly.[63]

Conclusion

As the employment of bariatric surgery to manage morbid obesity in adults keeps rising, surgeons must be mindful of pre-existing nutritional insufficiencies in obese patients submitted for bariatric procedures and these insufficiencies should be early disclosed to eschew post-operative adverse effects. The severity of vitamin D deficiency after bariatric surgery is related to the type of bariatric procedures implemented, the amount and rate of weight loss, and the degree of malabsorption of other micro- and macro-nutrients. Long-term follow-up monitoring and supplementation should be provided according to the type of procedure and the individual patient's risk for adverse events. Patients programmed for bariatric surgery should be motivated to restrict to proper dietary habits, physical activity, and vitamin D supplementations pre- and post-operatively.

References

1. Lobstein T., Jackson-Leach R., Moodie M. L., Hall K. D., Gortmaker S. L., Boyd A. S. et al. Child and adolescent obesity part of a bigger picture. *Lancet* 2015; 385:2510–2520. CrossRef

2. Lespessailles E., Toumi H. Vitamin D alteration associated with obesity and bariatric surgery. *Exp Biol Med (Maywood).* 2017;242:1086-1094. doi: 10.1177/1535370216688567. CrossRef
3. Santonicola A., Angrisani L., Ciacci C., Iovino P. Prevalence of functional gastrointestinal disorders according to Rome III criteria in Italian morbidly obese patients. *Sci World J.* 2013. doi: 10.1155/2013/532503. CrossRef
4. Al-Shehri F. S., Moqbel M. M., Al-Shahrani A. M., Al-Khaldi Y. M., Abu-Melha W. S. Management of obesity Saudi Clinical Guideline. *Saudi J Obesity.* 2013;1:18-30. CrossRef
5. Al-Hazzaa H. M. Physical activity prescription before bariatric surgery: Feasibility heal impacts and practical implications. *Saudi J Obesity.* 2016;4:3-12. CrossRef
6. McCullough P. A., Gallagher M. J., Dejong A. T., Sandberg K. R., Trivax J. E., Alexander D., *et al.* Cardiorespiratory fitness and short-term complications after bariatric surgery. *Chest.* 2006;130:517-25. CrossRef
7. Mechanick J. I., Kushner R. F., Sugerman H. J., Gonzalez-Campoy J. M., Collazo-Clavell M. L., Spitz A. F., *et al.* American Association of Clinical Endocrinologists, the Obesity Society and American Society for Metabolic & Bariatric Surgery medical guidelines for clinical practice for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient. *Obesity (Silver Spring)* .2009;17(1):S1-70. CrossRef
8. Efficacy of Vitamin D Supplementation in Bariatric Surgery Patients. Last updated 2015. Available at: https://clinicaltrials.gov/ct2/show/NCT01385098.
9. Lespessailles E, Toumi H. Vitamin D alteration associated with obesity and bariatric surgery. *Exp Biol Med (Maywood).* 2017. doi: 10.1177/1535370216688567. CrossRef
10. Durá-Travé T., Gallinas-Victoriano F., Chueca-Guindulain M. J., Berrade-Zubiri Prevalence of hypovitaminosis D and associated factors in obese Spanish children. *Nutrition & Diabetes.* 2017;7:248. doi:10.1038/nutd.2016.50. CrossRef
11. Wakayo T., Whiting S. J., Belachew T. Vitamin D Deficiency is Associated with Overweight and/or Obesity among Schoolchildren in Central Ethiopia: A Cross-Sectional Study.

Nutrients 2016;8:190. doi: 10.3390/nu8040190.
CrossRef

12. Mehmood Z. H., Papandreou D. An Updated Mini Review of Vitamin D and Obesity: Adipogenesis and Inflammation State. *Open Access Maced J Med Sci.* 2016;15;4:526-532.
CrossRef
13. Compston J. E., Vedi S., Ledger J. E., Webb A., Gazet J. C., Pilkington T. R. E. Vitamin D status and bone histomorphometry in gross obesity. *Am J Clin Nutr* 1981;34:2359–63.
CrossRef
14. Medicine J. H. Vitamin D levels linked to weight-loss surgery outcomes. Science Daily. 2015. <www.sciencedaily.com/releases/2015/12/151222163650.htm>.
15. Compston J. E., Vedi S., Ledger J. E., Webb A., Gazet J. C., Pilkington T. R. E. Vitamin D status and bone histomorphometry in gross obesity. *Am J Clin Nutr* 1981;34:2359–63.
CrossRef
16. Wortsman J., Matsuoka L. Y., Chen T. C., Lu Z and Decreased H. bioavailability of vitamin D in obesity. *Am J Clin Nutr.* 2000;72(3):690-693.
CrossRef
17. Grethen E., McClintock R., Gupta E. C., Jones M. R., Cacucci M. B., Diaz D., Fulford D. A., Perkins M. S., Considine V. R., Peacock M. Vitamin D and Hyperparathyroidism in Obesity. *J Clin Endocrinol Metab.* 2011;96:1320-1326.
CrossRef
18. McClintock R., Gupta C. E., Jones R., Cacucci B. M., Diaz D., Fulford A. D., Perkins S. M., Considine R. V., Peacock M. Vitamin D and Hyperparathyroidism in Obesity. *J Clin Endocrinol Metab.* 2011;96:1320-1326.
CrossRef
19. Blum M., Dolnikowski G., Seyoum E., Harris S. S., Booth S. L., Peterson J., Saltzman E., Dawson-Hughes B. Vitamin D_3 in fat tissue. *Endocrine.* 2008;33:90–94.
CrossRef
20. Stein E. M., Strain G., Sinha N., Ortiz D., Pomp A., Dakin G., McMahon D. J., Bockman R, sSilverberg SJ. Vitamin D insufficiency prior to bariatric surgery: risk factors and a pilot treatment study. *Clin Endocrinol (Oxf).* 2009;71:176–183.
CrossRef
21. Drincic A. T., Armas L. A.,Diest E. E. V., Heaney R. P. Volumetric dilution, rather than sequestration best explains the low vitamin D status of obesity. *Obesity (Silver Spring).* 2012;20:1444–1448.
CrossRef

22. Essouma M and Noubiap J. J. N. Are Systematic Screening for Vitamin D Deficiency and Vitamin D Supplementation Currently Feasible for Ankylosing Spondylitis Patients? *International Journal of Inflammation.* 2017. Article ID 7840150. https://doi.org/10.1155/2017/7840150
CrossRef
23. Bellia A., Garcovich C., D'Adamo M., Lombardo M., Tesauro M., Donadel G Gentileschi P., Lauro D., Federici M., Lauro R., *et al.* Serum 25-hydroxyvitamin D levels are inversely associated with systemic inflammation in severe obese subjects*. Intern. Emerg. Med.* 2013;8:33–40.
CrossRef
24. Rodriguez-Rodriguez E., Aparicio A., Andres P., Ortega R. M. Moderate vitamin D deficiency andinflammation related markers in overweight/obese schoolchildren. *J. Vitam. Nutr. Res.* 2014;84:98–107.
CrossRef
25. Chang E and Kim Y. Vitamin D Insufficiency Exacerbates Adipose Tissue Macrophage Infiltration and Decreases AMPK/SIRT1 Activity in Obese Rats. *Nutrients.* 2017;9:338; doi:10.3390/nu9040338.
CrossRef
26. Fontana L., Eagon J. C., Trujillo M. E., Scherer P. E., Klein S. Visceral fat adipokine secretion is associated with systemic inflammation in obese humans. *Diabetes.* 2007;56:1010–1013.
CrossRef
27. Antuna-Puente B., Feve B., Fellahi S., Bastard J. P. Adipokines: The missing link between insulin resistance and obesity. *Diabetes Metab.* 2008;34:2–11.
CrossRef
28. Koszowska A. U., Nowak J., Dittfeld A., Brończyk-Puzoń A., Kulpok A., Zubelewicz-Szkodzińska B. Obesity, adipose tissue function and the role of vitamin D. *Cent Eur J Immunol*. 2014;39(2):260-4.
CrossRef
29. Trayhurn P. Hypoxia and adipose tissue function and dysfunction in obesity. *Physiol Rev* 2013; 93:1-21.
CrossRef
30. Wellen K. E., Hotamisligil G. S. Obesity-induced inflammatory changes in adipose tissue. *J Clin Invest.* 2003;112:1785-8.
CrossRef

31. Higgins M. J., Mackie S. L., Thalayasingam N., Bingham S. J., Hamilton J., Kelly C. A. The effect of Vitamin D levels on the assessment of disease activity in rheumatoid arthritis. *Clin Rheumatol.* 2013;32:863-867.
CrossRef
32. Cantorna M. T., Mahon B. D. Mounting evidence for Vitamin D as an environmental factor affecting autoimmune disease prevalence. *Exp Biol Med (Maywood).* 2004;229:1136-1142.
CrossRef
33. de Souza W. N., Martini L. A. The role of Vitamin D in obesity and inflammation at adipose tissue. *J Obes Metab Res.* 2015;2:161-6.
CrossRef
34. Koszowska A., Nowak J., Dittfeld A., Brończyk-Puzoń A., Kulpok A., Zubelewicz-Szkodzińska B. Obesity adipose tissue function and the role of vitamin D. *Cent Eur J Immunol.* 2014;2:260–264.
CrossRef
35. Ghavamzadeh S., Mobasseri M., Mahdavi R. The Effect of Vitamin D Supplementation on Adiposity, Blood Glycated Hemoglobin, Serum Leptin and Tumor Necrosis Factor-α in Type 2 Diabetic Patients. *Int J Prev Med.* 2014; 5:1091–1098.
36. Maggi S., Siviero P., Brocco E., Albertin M., Romanato G., Crepaldi G. Vitamin D deficiency, serum leptin and osteoprotegerin levels in older diabetic patients: an input to new research avenues. *Acta Diabetol* 2013;51:461–469.
CrossRef
37. AL-Suhaimi E. A., Shehzad A. Leptin, resistin and visfatin: the missing link between endocrine metabolic disorders and immunity. *Eur J Med Res.* 2013;18:1–13.
CrossRef
38. Sabry D., Al-Ghussein M., Hamdy G., Abul-Fotouh A., Motawi T., El Kazaz A., et al. Effect of vitamin D therapy on interleukin-6, visfatin and hyaluronic acid levels in chronic hepatitis C Egyptian patients. *Clin Risk Manag.* 2015;11:279–288.
CrossRef
39. Reyman M.,Stuart A. A. V., van Summeren M., Rakhshandehroo M., Nuboer R., de Boer F. K., van den Ham H. J., Kalkhoven E., Prakken B., Schipper H. S. Vitamin D deficiency in childhood obesity is associated with high levels of circulating inflammatory mediators, and low insulin sensitivity. *Int J Obes (Lond).* 2014; 38:46-52.
CrossRef
40. Lespessailles E., Toumi H. Vitamin D alteration associated with obesity and bariatric surgery. *Exp Biol Med (Maywood).* 2017;242:1086-1094.

CrossRef
41. Peterson L. A., Zeng X., Caufield-Noll C. P., Schweitzer M. A., Magnuson T. H., Steele K. E. Vitamin D status and supplementation before and after bariatric surgery a comprehensive literature review. *Surg Obes Relat Dis.* 2016;12:693-702.
CrossRef
42. Shekelle P. G., Newberry S., Maglione M., Li Z., Yermilov I., Hilton L., Suttorp M., Maggard M., Carter J., Tringale C., Chen S. Bariatric surgery in women of reproductive age: special concerns for pregnancy. *Evid Rep Technol Assess (Full Rep).* 2008;(169):1-51. Review.
CrossRef
43. Kim J and Brethauer S. Metabolic bone changes after bariatric surgery. *Surg Obes Relat Dis.* 2015;11:406. http://dx.doi.org/10.1016/j.soard.2014.03.010.
CrossRef
44. Cena H.,Giuseppe R. D., Biino G., Persico F., Ciliberto A., Giovanelli A., Stanford FC. Evaluation of eating habits and lifestyle in patients with obesity before and after bariatric surgery a single Italian center experience. *Springerplus* 2016; 5(1):1467. doi: 10.1186/s40064-016-3133-1. eCollection 2016.
CrossRef
45. Al-Hazza H. M. Physical activity prescription before bariatric surgery: Feasibility, health impacts and practical implications. *Saudi Journal of Obesity.* 2016;4:3-12.
CrossRef
46. Pories W. J. Bariatric Surgery: Risks and Rewards. *J Clin Endocrinol Metab.* 2008;93(11 Suppl 1):S89–S96. doi: 10.1210/jc.2008-1641.
CrossRef
47. Xanthakos S. A. Nutritional Deficiencies in Obesity and After Bariatric Surgery. *Pediatr Clin North Am.* 2009;56:1105–1121.
CrossRef
48. Aarts E., van Groningen L., Horst R., Telting D., van Sorge A., Janssen I., de Boer H. Vitamin D absorption: consequences of gastric bypass surgery. *European Journal of Endocrinology.* 2011;164:827–832.
CrossRef
49. Johnson J. M., Maher J. W., De Maria E. J., Downs R. W., Wolfe L. G., Kellum J. M. The Long-term Effects of Gastric Bypass on Vitamin D Metabolism. *Annals of Surgery.* 2006;243:701-705. doi:10.1097/01.sla.0000216773.47825.c1.
CrossRef
50. Moore C. E., Sherman V. Vitamin D supplementation efficacy: sleeve gastrectomy versus gastric bypass surgery. *Obes Surg.* 2014;24:2055-2060.

CrossRef

51. Peterson L. A., Canner J. K., Cheskin L. J., Prokopowicz G. P., Schweitzer M. A., Magnuson T. H and Steele K. E. Proxy measures of vitamin D status – season and latitude – correlate with adverse outcomes after bariatric surgery in the Nationwide Inpatient Sample, 2001–2010: a retrospective cohort study. *Obesity Science & Practice.* 2015;1:88–96. doi: 1002/osp4.15.
CrossRef
52. Borges J. L. C., Miranda I. S. M., Sarquis M. M. S., Borba V., Maeda S. S., Lazaretti-Castro M., Obesity N. B., Surgery B and Vitamin D. *J Clin Densitom* 2017. doi: 10.1016/j.jocd.2017.03.001.
CrossRef
53. Cole A. J., Beckman L. M., Earthman C. P. Vitamin D status following bariatric surgery: implications and recommendations. *Nutr Clin Pract.* 2014;29:751-8.
CrossRef
54. King R. J., Chandrajay D., Abbas A., Orme S. M., Barth J. H. High-dose oral colecalciferol loading in obesity: impact of body mass index and its utility prior to bariatric surgery to treat vitamin D deficiency. *Clin Obes.* 2017;7:92–97. doi:10.1111/cob.12176.
55. Heaney R. P. Functional indices of vitamin D status and ramifications of vitamin D deficiency. *Am J Clin Nutr*. 2004;80(suppl):1706–1709.
56. Dawson-Hughes B., Heaney R. P., Holick M. F., et al. Estimates of optimal vitamin D status. *Osteoporosis Int*. 2005;16(7):713-6.
57. Peterson L. A. Bariatric surgery and vitamin D: key messages for surgeons and clinicians before and after bariatric surgery. *Minerva Chir.* 2016;71:322-36.
58. Chakhtoura M. T., Nakhoul N. N., Shawwa K., Mantzoros C., Fuleihan G. A. E. Hypovitaminosis D in bariatric surgery: A systematic review of observational studies. *Metabolism.* 2016;65:574-85. doi: 10.1016/j.metabol.2015.12.004.
59. Magouliotis D. E., Tasiopoulou V. S., Sioka E., Chatedaki C., Zacharoulis D. Impact of Bariatric Surgery on Metabolic and Gut Microbiota Profile: A Systematic Review and Meta-Analysis. *Obes Surg.* 2017;27:1345-1357.
60. Chakhtoura M. T., Nakhoul N., Akl E. A., Mantzoros C. S., Fuleihan G. A. E. Guidelines on vitamin D replacement in bariatric surgery: Identification and systematic appraisal. *Metabolism.* 2016;65(4):586-97.
61. Peterson L. A. Early, Personalized Vit D Needed After Bariatric Surgery. 2016 Available at: https://www.medpagetoday.com/primarycare/obesity/57281.
62. Chakhtoura M. T., Nakhoul N., Akl E. A., Mantzoros C. S., Fuleihan G. A. E. Guidelines on vitamin D replacement in bariatric surgery: Identification and systematic

appraisal. *Metabolism.* 2016. http://dx.doi.org/10.1016/j.metabol.2015.12.013

63. Stokes C. S and Lammert F. Vitamin D supplementation: less controversy, more guidance needed [version 1; referees: 3 approved]. *F1000Research.* 2016;5(F1000 Faculty Rev). 2017 (doi: 10.12688/f1000research.8863.1

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