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Original Article

Therapeutic and Metabolic role of VIT D in psoriasis and psoriatic arthritis

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Abstract

Psoriasis is a chronic inflammatory skin condition marked by scaly, hardened red plaques, which extend beyond the skin to affect joints and nails. It is often associated with systemic, psychiatric, and psychosocial disorders. Keratinocytes are fundamental in both initiating and maintaining psoriasis as part of the body's innate immune response. These skin cells can react to various environmental stimuli. When stressed, keratinocytes release self-nucleotides and antimicrobial peptides, which in turn activate plasmacytoid dendritic cells (pDCs). This leads to the activation and maturation of myeloid dendritic cells (mDCs), which produce pro-inflammatory cytokines such as IFN-α, IFN-γ, TNF-α, and IL-1β Vitamin D helps maintain the health of the skeletal system and epidermis, regulatin keratinocyte differentiation and proliferation. There is a strong connection between vitamin D and the IL-33/ST2 axi in regulating skin and bone homeostasis. This review explores the bidirectional interactions between vitamin D and psoriasis, suggesting a mechanistic link with IL-33 in patients suffering from psoriasis and related osteoporosis (OP).

Keywords: Vitamin D, Psoriasis; Psoriatic arthritis, keratinocytes.
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Introduction

Psoriasis is a persistent inflammatory dermal illness, marked by the development of scaly red plaques. It can also impact joints and nails. The disease exhibits three primary histologic features: epidermal thickening, enlarged vessels in the dermis, and an inflammatory infiltration of immune cells, especially leucocytes in the dermis. [1] Psoriasis is categorized into three forms: psoriasis vulgaris, psoriatic arthritis, and generalized pustular psoriasis (GPP). It often accompanied with other systemic conditions such as hyperlipidemia, obesity, hypertension, hyperlipidemia, and cardiovascular disease. [2] Additionally, patients may experience psychiatric conditions and psychosocial distress.[3, 4]

Epidemiology:

It affects both men and women, with a higher prevalence and earlier onset in women, particularly those having a family history. It can develop at any age, though onset peaks in males between 30–39 and 60–69, and 10 years earlier in females. Around 60 million people worldwide are affected, with higher rates observed in developed regions and elderly subjects.[5, 6]

Pathogenesis:

Psoriasis is largely driven by dendritic cells and T cells, although macrophages, neutrophils, keratinocytes, and endothelial cells also contribute. Keratinocytes play an important role in the disease's initiation and maintenance, responding to various triggers and producing inflammatory molecules that amplify the immune response.[7]

Keratinocytes' role in psoriasis pathogenesis

Keratinocytes are fundamental in both initiating and maintaining psoriasis as portion of the body's innate immune response. Such skin cells can react to various environmental stimuli. When stressed, these cells release antimicrobial peptides and self-nucleotides, which in turn activate plasmacytoid dendritic cells (pDCs). This leads to the stimulation and maturation of myeloid dendritic cells (mDCs), which produce pro-inflammatory cytokines .[8]

Beyond the initial phase, keratinocytes amplify psoriatic inflammation during the disease's chronic stage.[9] When triggered by inflammatory cytokines, keratinocytes proliferate rapidly and secrete numerous chemokines to recruit immune cells like macrophages, neutrophils, dendritic and Th17 cells. These cells, along with antimicrobial peptides (AMPs), contribute to the body's innate immune response and further promote inflamemation .[10]

The interaction between immune cells, particularly Th17 cells and kerainocytes, leads to the activation and persistence of psoriasis. This includes keratinocytes' hyperproliferation and abnormal differentiation, vessels'dilation and thickening, and inflammatory cells' infiltration.[10, 11] The underlying mechanisms of psoriasis involve various elements such as AMPs, dendritic cells (DCs), tumor necrosis factor (TNF) α, interleukin (IL) 23, Th17 cells, IL-17, IL-22, and the signal transducer and activator of transcription (STAT) 3. Keratinocytes produce AMPs like β-defensins, S100 proteins, and cathelicidin. Meanwhile, mDCs generate TNFα, IL23, and IL12.[4]

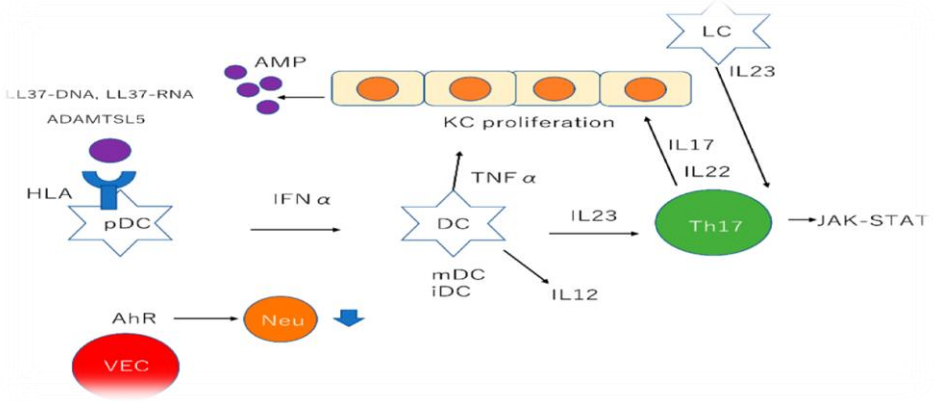

Fig (1): pathogenesis of psoriasis.

Clinical presentation:

Psoriasis manifests with a variety of clinical forms that vary in lesion size and distribution .[11] Its manifestations exhibit in many forms: plaque, flexural, guttate, and pustular or erythrodermic psoriasis. Psoriasis lesions are marked by abnormal epidermal keratinocyte proliferation, incomeplete differentiation, and reduced keratinocyte apoptosis, accompanied by inflammatory cell infiltration in both the dermis and epidermis. [12]Plaque psoriasis is the most common type, presenting as well-defined, salmon-colored scales covered with silvery plaques. These lesions typically appear symmetrically on the extensor surfaces, such as the elbows, knees, trunk, and scalp. Bleeding points, known as Auspitz sign, may appear when the scales are scraped off. Flexural psoriasis, on the other hand, tends to have less scaling and can affect areas like the axillae, sub-mammary, and genital regions. Guttate psoriasis is characterized by a sudden onset of small, drop-like papules or plaques that mostly affect the trunk and limbs. It is often preceded by a streptococcal infection. Guttate psoriasis cases may eventually experience plaque psoriasis. In rare, severe individuals with uncontrolled condition, psoriasis can lead to erythroderma, a widespread red rash that can be life-threatening, with complications such as hypothermia, infection risks, acute kidney injury, and high-output cardiac failure. The "Koebner phenomenon" refers to the development of lesions in areas of the skin that have been subjected to trauma. [13] The severity and extent of psoriasis are typically assessed using the "Psoriasis Area and Severity Index (PASI) score". [14]

Vitamin D and psoriasis

Vitamin D, commonly referred to as the 'sunshine vitamin,' is a hormone known for regulating calcium and phosphorus balance and maintaining skeletal health .[15] It is naturally synthesized in the skin through exposure to ultraviolet B (UVB) light from the sun or other UVB sources. [16] In addition to its well-established role in bone health, vitamin D may also play a potential role in modulating immune responses and inflammation. [17]

Recent studies have highlighted vitamin D's involvement in the development of various dermal conditions, including psoriasis [17–19] Nonetheless, the use of vitamin D as a supplementary treatment for psoriasis remains a topic of debate and is still not fully established. [17–19] This review explores the potential bi-directional relationships between vitamin D and psoriasis, investigating how these interactions might influence the pathogenesis of the disease.

Vitamin D impact on dermal biology

It plays a critical and complex role as a regulator of skin biology. The epidermis consists of four layers: the basal, spinous, granular, and the outermost stratum corneum. Stem cells in the basal layer continuously divide and provide new cells that gradually migrate upward, differentiating and forming the skin's protective barrier. The process of skin differentiation is tightly regulated and occurs in a sequential manner. [19, 20] The vitamin precursor, 7-dehydrocholesterol, resides in the membranes of keratinocytes in the basal and spinous layers .[21]drocholesterol undergoes a photochemical reaction that results in the formation of pre-vitamin D3 (cholecalciferol), which is then transformed to the active type, 1,25-hydroxyvitamin D (calcitriol), by enzymatic activity in the skin. [22]

Calcitriol and its receptor have a potential role in regulating keratinocyte differentiation, proliferation, and apoptosis, as well as modulating the immune system of the skin. 1,25-hydroxyvitamin D has been shown to inhibit the proliferation of keratinocytes.[23] Additionally, calcitriol and its analogs reduce the expression of S100A7, a protein commonly increased in psoriasis .[20, 24-26] Moreover, 1,25(OH)D promotes generation of keratins (K1 & K10), involucrin, loricrin, and filaggrin, which are essential for maintaining the skin's barrier function .[21, 20, 22] Vitamin D also regulates the synthesis of glycosylceramides in the stratum corneum, which are crucial for maintaining barrier integrity and skin permeability. [20, 21, 24] These effects are attributed to vitamin D's ability to organize intracellular calcium levels through the receptors and phospholipase C enzymes. [26, 27] 1,25(OH)D deficiency or malfunction of its receptor can impair skin differentiation, leading to reduced levels of structural proteins like involucrin and loricrin and promoting basal layer hyperproliferation .[21,28-30]

Effect of vitamin D in psoriasis associated osteoarthritis

Vitamin D and the IL-33/ST2 axis have an interconnected role in maintaining both skin and bone homeostasis. However, the precise function of vitamin D in modulating IL-33 activity, which is involved in the pathogenesis of psoriasis-associated osteoporosis (OP), remains a topic of ongoing debate. [31, 32] It is believed that vitamin D and IL-33 share common signaling pathways and may rely on each other to regulate critical immune and metabolic processes in both the skin and bone. Evidence suggests that, in certain biological contexts, vitamin D and IL-33 work synergistically, while in other situations, they act to regulate and modulate each other's activities. In this review, we propose a mechanistic link between vitamin D and IL-33 in cases suffering from psoriasis and its linked osteoporosis, offering insights into their potential joint role in disease progression. [33]

Vitamin D and IL-33 Crosstalk

IL-33 shares many immunoregulatory functions with vitamin D, either enhancing or modulating their effects. It is synthesized by cells that are controlled by vitamin D, and their tissue targets and signaling pathways often overlap. IL-33 and vitamin D stimulate Th2 lymphocytes differentiation while blocking Th1 differentiation, and they also induce regulatory immune cells. Vitamin D is capable of downregulating the generation of inflammatory chemokines and cytokines. [34]

The activity of vitamin D is mediated through its receptors, which are present bones and various other cells, including keratinocytes, antigen-presenting and immune cells. Specifically, dendritic cells, monocytes, lymphocytes, neutrophils, and epithelial cells are involved in the production of IL-33 and other cytokines that contribute to bone remodeling and psoriasis-related inflammation. [35-37] IL-33, therefore, has a considerable role in orchestrating the immune responses associated with psoriasis, as well as bone remodeling. [38]

Vitamin D is pivotal in regulating both bone turnover and immune responses. Additionally, it is involved in maintaining homeostasis, being a potent immune modulator and inhibiting DC maturation. In psoriasis patients, and especially in those with associated osteoporosis, serum vitamin D levels are typically reduced. [36]

Vitamin D low levels have been studied in both psoriasis and osteoporosis. Recent research has also highlighted the significant role of IL-33 in these conditions. Th2-related cytokines have been found to influence bone remodeling, skin inflammation, and psoriatic arthritis. [37, 38] IL-33 acts as an alarmin, triggering both repair and damaging processes, while functioning as a nuclear transcription factor. Similarly, vitamin D regulates gene transcription via its receptor, which acts as a ligand-activated transcription factor. [34]

The relationship between vitamin D and IL-33 is highly complex and context-dependent. For instance, IL-33 participates in inflammation associated with deficiency of vitamin D, but it may also counterbalance some of its harmful impacts, based on the clinical context and the cytokine milieu. Both vitamin D and IL-33 are thought to exert protective effects against osteoporosis in the bone environment, but their combined effects in inflamed psoriatic skin and psoriatic arthritis could potentially amplify the negative impact of deficiency and activation of the IL-33/ST2 axis. [39, 40]

In allergic inflammatory diseases, both low vitamin D levels and increased IL-33 have been linked to Th2 immunity, suggesting opposing roles in allergic conditions. [41] proposing that they play conflicted roles in allergies. Therefore, a complex interaction between vitamin D and IL-33 has been proposed, which extends beyond allergies to other conditions such as psoriasis and osteoporosis. Vitamin D promotes the synthesis of anti-inflammatory IL-10 by stimulating expression of α-1-antitrypsin in CD4+ T cells, limiting Th2 differentiation during allergic inflammation. [42]

Conversely, IL-33 provokes Th2 cytokines production, including IL-31, which plays a potential role in recruiting and activating effector cells in allergic responses. IL-31, generated by CD4+ T cells, has a strong immunological connection with IL-33 and contributes to allergic inflammation, atopic dermatitis, and psoriasis. Similarly, this interaction is also involved in modifying bone remodeling in osteoporosis, with receptors for IL-31 and IL-33 playing important roles in the pathophysiology of both psoriasis and osteoporosis. [43, 44]

The modification of the bone remodeling process that causes osteoporosis has been linked to a similar intimate connection. The immunopathological processes of osteoporosis and psoriasis are associated with the IL-33 receptor ST2, the oncostatin M receptor, and the IL-31 receptor IL-31RA. The synthesis of IL-31 is stimulated by the ST2 receptor of IL-33, which is an essential part of Th2 responses. **(45)**

The soluble ST2 receptor (sST2), which is elevated in psoriasis, acts as a decoy IL-33 receptor, inhibiting the IL-33/ST2 signaling axis. A disruption in this axis has been shown to significantly contribute to osteoporosis. **(31)** Elevated sST2 levels correlate with reduced bone mineral density (BMD) and compromised bone microstructure in psoriasis. Vitamin D helps regulate sST2 levels, potentially alleviating inflammation in psoriatic skin. **(46)** The link between increased sST2 and decreased vitamin D levels in psoriasis may contribute to the detrimental effects of inflammatory mediators on bone quality and osteoporosis. Vitamin D and IL-33 influence Treg cell activity, which is crucial for tissue repair and maintaining skin and bone homeostasis. A deficiency in either vitamin D or IL-33 may result in Treg cell dysfunction, impacting the inflammatory processes of psoriasis. **(47)** IL-33 promotes Treg recruitment to inflammation sites, where they suppress inflammation and protect bone. Vitamin D may enhance these immune regulatory effects by inducing Treg cells, whereas low vitamin D levels in psoriasis patients may lead to a reduced number of circulatory Tregs, further destabilizing immune homeostasis. **(48)**

Vitamin D also modulates function of CD4+ T cell by reversing defective IL-10-secreting Treg cell induction. IL-33 stimulates IL-10-generating regulatory B cells and enhances IL-10 generation in macrophages, contributing to the increased prevalence of osteoporosis in psoriasis patients. **(49)**

References

1. **Griffiths CEM, Barker JNWN.** Pathogenesis and clinical features of psoriasis. Lancet. 2007;370(9583):263-71. doi:10.1016/S0140-6736(07)61128-3.

2. **Yamanaka K, Mizutani H.** Inflammatory skin march: IL-1-mediated skin inflammation, atopic dermatitis, and psoriasis to cardiovascular events. J Allergy Clin Immunol. 2015;136(3):823-824. doi: 10.1016/j.jaci.2015.06.009.

3. **Tang L, Yang X, Liang Y, Xie H, Dai Z, Zheng G.** Transcription factor retinoid-related orphan receptor γt: a promising target for the treatment of psoriasis. Front Immunol. 2018; 9:1210. doi:10.3389/fimmu.2018.01210

4. **Tokuyama M, Mabuchi T.** New treatment addressing the pathogenesis of psoriasis. Int J Mol Sci. 2020;21(20):7488. doi:10.3390/ijms21207488.

5. **Parisi R, Iskandar IY, Kontopantelis E, Augustin M, Griffiths CE, Ashcroft DM.** National, regional, and worldwide epidemiology of psoriasis: systematic analysis and modelling study. BMJ. 2020;369:m1590. doi:10.1136/bmj.m1590

6. **Jemal A, Bray F, Center MM, Ferlay J, Ward E, Forman D.** Global cancer statistics. CA Cancer J Clin. 2011;61(2):69-90. doi:10.3322/caac.20107.

7. **Kim TG, Kim DS, Kim HP, Lee MG.** The pathophysiological role of dendritic cell subsets in psoriasis. BMB Rep. 2014;47(2):60-8. doi:10.5483/BMBRep.2014.47.2.014.

8. **Greb JE, Goldminz AM, Elder JT, Lebwohl MG, Gladman DD, Wu JJ, et al.** Psoriasis. Nat Rev Dis Primers. 2016; 2:16082. doi:10.1038/nrdp.2016.82.

9. **Lowes MA, Russell CB, Martin DA, Towne JE, Krueger JG.** The IL-23/T17 pathogenic axis in psoriasis is amplified by keratinocyte responses. Trends Immunol. 2013;34(4):174-81. doi:10.1016/j.it.2012.11.005.

10. **Wang Z, Zhou H, Zheng H, Zhou X, Shen G, Teng X, et al.** Autophagy-based unconventional secretion of HMGB1 by keratinocytes plays a pivotal role in psoriatic skin inflammation. Autophagy. 2021;17(2):529-52. doi:10.1080/15548627.2020.1725381.

11. **Napolitano M, Caso F, Scarpa R, Megna M, Patrì A, Balato N, et al**. Psoriatic arthritis and psoriasis: differential diagnosis. Clin Rheumatol. 2016;35(8):1893-901. doi:10.1007/s10067-016-3295-9.

12. **Lowes MA, Suárez-Fariñas M, Krueger JG.** Immunology of psoriasis. Annu Rev Immunol. 2014; 32:227-55. doi:10.1146/annurev-immunol-032713-120225.

13. **Raharja A, Mahil SK, Barker JN.** Psoriasis: a brief overview. Clin Med (Lond). 2021;21(3):170-3.

14. **Harari M, Shani J, Hristakieva E, Stanimirovic A, Seidl W, Burdo A.** Clinical evaluation of a more rapid and sensitive psoriasis assessment severity score (PASS), and its comparison with the classic method of psoriasis area and severity index (PASI), before and after climatotherapy at the Dead Sea. Int J Dermatol. 2000;39(12):913-8.

15. **Holick MF.** Vitamin D deficiency. N Engl J Med. 2007;357(3):266-281. doi:10.1056/NEJMra070553

16. **Kovács S, Wilkens MR, Liesegang A.** Influence of UVB exposure on the vitamin D status and calcium homeostasis of growing sheep and goats. J Anim Physiol Anim Nutr (Berl). 2015; 99:1-12.

17. **Mattozzi C, Paolino G, Richetta AG, Calvieri S.** Psoriasis, vitamin D and the importance of the cutaneous barrier's integrity: an update. J Dermatol. 2016;43(5):507-14.

18. **Wadhwa B, Relhan V, Goel K, Kochhar AM, Garg VK**. Vitamin D and skin diseases: a review. Indian J Dermatol Venereol Leprol. 2015;81(4):344-55.

19. **Soleymani T, Hung T, Soung J.** The role of vitamin D in psoriasis: a review. Int J Dermatol. 2015;54(4):383-92.

20. **Reichrath J**. Vitamin D and the skin: An ancient friend, revisited. Exp Dermatol. 2007;16(7):618-25.

21. **Hawkes JE, Chan TC, Krueger JG**. Psoriasis pathogenesis and the development of novel targeted immune therapies. J Allergy Clin Immunol. 2017;140(3):645-53.

22. **Bikle DD**. Protective actions of vitamin D in UVB induced skin cancer. Photochem Photobiol Sci. 2012;11(12):1808-16.

23. **Matsumoto K, Hashimoto K, Nishida Y, Hashiro M, Yoshikawa K.** Growth-inhibitory effects of 1,25-dihydroxyvitamin D3 on normal human keratinocytes cultured in serum-free medium. Biochem Biophys Res Commun. 1990;166(2):916-23.

24. **Gniadecki R**. Stimulation versus inhibition of keratinocyte growth by 1,25-dihydroxyvitamin D3: dependence on cell culture conditions. J Invest Dermatol. 1996;106(3):510-6.

25. **Datta Mitra A, Raychaudhuri SP, Abria CJ, Mitra A, Wright R, Ray R, et al.** 1α,25-dihydroxyvitamin-D3-3-bromoacetate regulates AKT/mTOR signaling cascades: a therapeutic agent for psoriasis. J Invest Dermatol. 2013;133(6):1556-64.

26. **Hegyi Z, Zwicker S, Bureik D, Peric M, Koglin S, Batycka-Baran A, et al.** Vitamin D analog calcipotriol suppresses the Th17 cytokine-induced proinflammatory S100 alarmins psoriasin (S100A7) and koebnerisin (S100A15) in psoriasis. J Invest Dermatol. 2012;132(5):1416-24.

27. **Tu CL, Oda Y, Komuves L, Bikle DD**. The role of the calcium-sensing receptor in epidermal differentiation. Cell Calcium. 2004; 35:265-73.

28. **Xie Z, Bikle DD.** Cloning of the human phospholipase C-γ1 promoter and identification of a DR6-type vitamin D-responsive element. J Biol Chem. 1997; 272:6573-7.

29. **Bikle DD.** Vitamin D regulated keratinocyte differentiation. J Cell Biochem. 2004; 92:436-44.

30. **Xie Z, Komuves L, Yu QC, Elalieh H, Ng DC, Leary C, et al.** Lack of the vitamin D receptor is associated with reduced epidermal differentiation and hair follicle growth. J Invest Dermatol. 2002; 118:11-6

31. **De Martinis M, et al.** IL-33/IL-31 axis in osteoporosis. Int J Mol Sci. 2020;21(4):1239.

32. **Shen J, et al**. Carotid plaque and bone density and microarchitecture in psoriatic arthritis: the correlation with soluble ST2. Sci Rep. 2016; 6:32116.

33. **Bonanno A, et al.** 25-Hydroxyvitamin D, IL-31, and IL-33 in children with allergic disease of the airways. Mediators Inflamm. 2014; 2014:520241.

34. **Annalora AJ, et al**. Alternative splicing of the vitamin D receptor modulates target gene expression and promotes ligand-independent functions. Toxicol Appl Pharmacol. 2019; 364:55-67.

35. **Raimondo A, et al**. Psoriatic cutaneous inflammation promotes human monocyte differentiation into active osteoclasts, facilitating bone damage. Eur J Immunol. 2017;47(6):1062-74.

36. **Janeva-Jovanovska E, et al.** Relationship between vitamin D, inflammation and lung function in patients with severe uncontrolled asthma. Open Access Maced J Med Sci. 2017;5(7):899.

37. **Balato A, et al**. IL-33 is secreted by psoriatic keratinocytes and induces pro-inflammatory

cytokines via keratinocyte and mast cell activation. Exp Dermatol. 2012;21(11):892-4.

38. **Schulze J, et al**. Interleukin-33 is expressed in differentiated osteoblasts and blocks osteoclast formation from bone marrow precursor cells. J Bone Miner Res. 2011;26(4):704-17.

39. **Kusuba N, et al**. Inhibition of IL-17–committed T cells in a murine psoriasis model by a vitamin D analogue. J Allergy Clin Immunol. 2018;141(3):972-81.

40. **Gao M, et al.** Low levels of vitamin D and the relationship between vitamin D and Th2 axis-related cytokines in neuromyelitis optica spectrum disorders. J Clin Neurosci. 2019; 61:22-7.

41. **Cayrol C, Girard JP**. Interleukin-33 (IL-33): a nuclear cytokine from the IL-1 family. Immunol Rev. 2018;281(1):154-68.

42. **Mahlakõiv T, et al.** Stromal cells maintain immune cell homeostasis in adipose tissue via production of interleukin-33. Sci Immunol. 2019;4(35): eaax0416.

43. **De Martinis M, Sirufo MM, Ginaldi L**. Allergy and aging: an old/new emerging health issue. Aging Dis. 2017;8(2):162-70.

44. **Coomes S, et al.** CD4+ Th2 cells are directly regulated by IL-10 during allergic airway inflammation. Mucosal Immunol. 2017;10(1):150-61.

45. **Duan Y, et al**. IL-33 contributes to disease severity in psoriasis-like models of mouse. Cytokine. 2019; 119:159-67.

46. **Vocca L, et al.** IL-33/ST2 axis controls Th2/IL-31 and Th17 immune response in allergic airway diseases. Immunobiology. 2015;220(8):954-63.

47. **Ginaldi L, et al.** Interleukin-33 serum levels in postmenopausal women with osteoporosis. Sci Rep. 2019;9(1):3786.

48. **Pfeffer PE, et al**. Vitamin D enhances production of soluble ST2, inhibiting the action of IL-33. J Allergy Clin Immunol. 2015;135(3):824-7.

49. **Zhang L, et al**. Characterization of Th17 and FoxP3+ Treg cells in paediatric psoriasis patients. Scand J Immunol. 2016;83(3):174-80.

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