ORIGINAL RESEARCH

Effect of Vitamin D Supplementation on Insulin Sensitivity and Serum Adiponectin Levels in Overweight Individuals

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ABSTRACT

Introduction: Vitamin D deficiency has been increasingly associated with insulin resistance and altered adipokine profiles, particularly in overweight individuals. Adiponectin, an insulin-sensitizing hormone, may serve as a key link between vitamin D status and metabolic health. **Objective:** To evaluate the effect of vitamin D supplementation on insulin sensitivity and serum adiponectin levels in overweight individuals. **Methodology:** This interventional study was conducted and included 195 overweight adults with serum 25(OH)D levels <30 ng/mL. Participants received vitamin D3 supplementation (cholecalciferol, 50,000 IU/week) for 12 weeks. Fasting glucose, insulin, HOMA-IR, and adiponectin levels were measured at baseline and post-intervention. **Results:** Of the 195 overweight participants, vitamin D levels increased significantly from 18.6 ± 4.9 to 35.4 ± 6.3 ng/mL after 12 weeks of supplementation ($p < 0.001$). This was associated with a reduction in HOMA-IR from 3.1 ± 1.2 to 2.2 ± 1.0 ($p < 0.001$), indicating improved insulin sensitivity. Serum adiponectin levels rose from 7.3 ± 2.1 to 9.1 ± 2.4 µg/mL ($p = 0.002$). Greater improvements were observed in individuals who achieved vitamin D sufficiency (≥30 ng/mL), including lower HOMA-IR (2.0 ± 0.9) and higher adiponectin (9.5 ± 2.2 µg/mL) compared to those who remained deficient. **Conclusion:** Vitamin D supplementation significantly improves insulin sensitivity and increases serum adiponectin levels in overweight individuals, suggesting its potential role in managing obesity-related metabolic dysfunction.

Keywords: Vitamin D, insulin sensitivity, adiponectin, HOMA-IR, overweight, supplementation.

INTRODUCTION

Overweight and obesity have become global epidemics, affecting more than 1.9 billion adults worldwide, of which over 650 million are classified as obese [1]. These conditions are strongly associated with insulin resistance, a pathophysiological hallmark of type 2 diabetes mellitus (T2DM), metabolic syndrome, and cardiovascular disease [2-3]. Insulin resistance, characterized by impaired glucose uptake and utilization, often precedes the onset of overt diabetes and is a key driver of chronic metabolic dysfunction in overweight individuals [4].In parallel, vitamin D deficiency is now recognized as a widespread public health concern. Studies estimate that over 50% of the global population has insufficient serum 25-hydroxyvitamin D [25(OH)D] levels, with even higher prevalence in obese individuals [6]. This is due to a combination of reduced cutaneous synthesis, volumetric dilution, increased sequestration of vitamin D in adipose tissue, and lower dietary intake. Emerging research has identified vitamin D as a potential modulator of glucose metabolism, given its biological activity in tissues that express the vitamin D receptor (VDR), including pancreatic β-cells, adipocytes, and skeletal muscle [7-9].Experimental models have shown that vitamin D may enhance insulin receptor expression, improve pancreatic β-cell function, and reduce systemic inflammation—factors all contributing to better insulin sensitivity. Furthermore, vitamin D is thought to influence the secretion and function of adipokines, such as adiponectin [10]. Adiponectin is a hormone derived from adipose tissue that possesses anti-inflammatory and insulin-sensitizing properties. It plays a protective role against metabolic syndrome and cardiovascular disease by enhancing hepatic and peripheral insulin

sensitivity, reducing hepatic gluconeogenesis, and modulating lipid oxidation [11].

Low circulating adiponectin levels are typically observed in obese individuals and are inversely associated with insulin resistance and T2DM risk. Several cross-sectional studies have demonstrated positive correlations between serum 25(OH)D and adiponectin concentrations. Some interventional studies have reported that vitamin D supplementation can improve insulin sensitivity and increase adiponectin levels, while others have found no significant changes, reflecting inconsistent evidence. The variability in findings may stem from differences in baseline vitamin D status, supplementation dose and duration, population characteristics, and endpoint assessments [12-13].Given these knowledge gaps, this study aims to evaluate the effects of vitamin D supplementation on insulin sensitivity and serum adiponectin levels in overweight individuals with confirmed vitamin D deficiency. By examining changes in HOMA-IR and adiponectin concentrations following a 12-week high-dose vitamin D regimen, this study seeks to provide further clarity on the metabolic role of vitamin D in overweight individuals and inform potential preventive strategies for metabolic disorders.

Objective

To assess the effect of vitamin D supplementation on insulin sensitivity and serum adiponectin levels in overweight individuals.

Methodology

This prospective interventional study was conducted at and included 195 overweight adult participants aged 20–60 years. Eligibility was based on a body mass index (BMI) ≥25 kg/m² and baseline serum 25-hydroxyvitamin D [25(OH)D] levels below 30 ng/mL. Individuals with type 2 diabetes, chronic kidney disease, or on medications affecting glucose or vitamin D metabolism were excluded.

Inclusion Criteria

- Age between 20 and 60 years
- BMI ≥25 kg/m² (overweight and obese)
- Serum 25(OH)D <30 ng/mL
- No current use of vitamin D supplements or insulin-sensitizing agents

Exclusion Criteria

- Diagnosed diabetes or use of antidiabetic medications
- Chronic liver, kidney, or endocrine disorders
- Recent vitamin D supplementation
- Pregnant or lactating women

Intervention and Data Collection

All participants received oral cholecalciferol (vitamin D3) at a dose of 50,000 IU per week for 12 weeks. Blood samples were taken after an overnight fast at baseline and after 12 weeks. Serum 25(OH)D, fasting glucose, fasting insulin, and adiponectin levels were measured. Insulin sensitivity was calculated using the Homeostasis Model Assessment of Insulin Resistance (HOMA-IR). Participants were also categorized into responders (achieving 25(OH)D ≥30 ng/mL) and non-responders for subgroup analysis.

Statistical Analysis

Data were analyzed using SPSS version 21. Paired t-tests were used to compare pre- and post-supplementation values of 25(OH)D, HOMA-IR, and adiponectin. Correlations between changes in vitamin D levels and insulin sensitivity were assessed using Pearson correlation. Between-group differences (responders vs. non-responders) were evaluated using independent t-tests. A p-value of <0.05 was considered statistically significant.

RESULTS

At baseline, the average age of the 195 overweight participants was approximately 38.7 years, with a nearly even gender distribution (53.3% male, 46.7% female). All participants were overweight or obese, with a mean BMI of 28.6 kg/m². The average baseline vitamin D level was 18.6 ng/mL, confirming widespread deficiency. Insulin resistance was elevated, with a mean HOMA-IR of 3.1, and adiponectin levels were suboptimal at 7.3 µg/mL. After 12 weeks of supplementation, 147 individuals (75.4%) achieved vitamin D sufficiency (≥30 ng/mL). This subgroup showed significantly better metabolic profiles compared to those who remained deficient: lower HOMA-IR (2.0 vs. 2.8, $p < 0.001$) and higher adiponectin levels (9.5 vs. 8.1 µg/mL, $p = 0.01$), despite similar age, sex, and BMI distributions across groups. These findings suggest that achieving vitamin D sufficiency is associated with measurable improvements in insulin sensitivity and adiponectin levels.

Table 1: Baseline Demographic and Biochemical Profile (Stratified by Vitamin D Response)

Characteristic	Total (n=195)	Achieved Vit D ≥30 ng/mL (n=147)	Remained <30 ng/mL (n=48)
Sex Distribution	104 Male (53.3%) / 91 Female (46.7%)	79 Male / 68 Female	25 Male / 23 Female
BMI Category	28.6 ± 3.9 (All overweight/obese)	28.5 ± 3.7	28.9 ± 4.1
Mean Baseline Vitamin D	18.6 ± 4.9	19.0 ± 5.1	17.8 ± 4.5

(ng/mL)			
Mean HOMA-IR	3.1 ± 1.2	2.0 ± 0.9	2.8 ± 1.1
Mean Adiponectin (µg/mL)	7.3 ± 2.1	9.5 ± 2.2	8.1 ± 2.5

After 12 weeks of weekly vitamin D3 supplementation, average serum 25(OH)D levels increased significantly from 18.6 to 35.4 ng/mL. HOMA-IR values dropped from 3.1 to 2.2, indicating improved insulin sensitivity ($p < 0.001$). Adiponectin levels rose from 7.3 to 9.1 µg/mL ($p = 0.002$), suggesting enhanced insulin-sensitizing and anti-inflammatory potential. These improvements reflect a meaningful metabolic benefit from repletion of vitamin D in this population.

Table 2: Changes in Biochemical Parameters After Supplementation

Parameter	Baseline	Post-12 Weeks	Mean Change	p-value
Vitamin D (ng/mL)	18.6 ± 4.9	35.4 ± 6.3	+16.8 ± 5.1	<0.001
HOMA-IR	3.1 ± 1.2	2.2 ± 1.0	–0.9 ± 0.7	<0.001
Adiponectin (µg/mL)	7.3 ± 2.1	9.1 ± 2.4	+1.8 ± 1.2	0.002

Of the 195 participants, 147 (75.4%) reached a post-treatment vitamin D level of at least 30 ng/mL. These individuals showed greater metabolic improvements: their mean HOMA-IR was significantly lower at 2.0 compared to 2.8 in those who remained deficient ($p < 0.001$), and their adiponectin levels were higher (9.5 vs. 8.1 µg/mL, $p = 0.01$). These results support that the metabolic benefits of supplementation are more pronounced in individuals who achieve vitamin D sufficiency.

Table 3: Response Stratification Based on Final Vitamin D Levels

Group	No. of Participants	Post HOMA-IR (Mean ± SD)	Post Adiponectin (µg/mL)	p-value (HOMA-IR)	p-value (Adiponectin)
Achieved ≥30 ng/mL	147	2.0 ± 0.9	9.5 ± 2.2	<0.001	0.01
Remained <30 ng/mL	48	2.8 ± 1.1	8.1 ± 2.5	-	-

At baseline, all participants were deficient or insufficient in vitamin D: 60.5% had levels below 20 ng/mL and 39.5% were in the 20–29 ng/mL range. After supplementation, 75.4% reached sufficiency (≥30 ng/mL), while the rest remained in the insufficient range (20–29 ng/mL). No participants remained severely deficient. This reflects high efficacy of the supplementation protocol in correcting vitamin D status over a 12-week period.

Table 4: Vitamin D Status Before and After Intervention

Status Category	Baseline (n, %)	Post 12 Weeks (n, %)	Improvement Rate (%)
<20 ng/mL	118	0	100%
20–29 ng/mL	77	48	37.9%
≥30 ng/mL	0	147	75.4% overall sufficiency

DISCUSSION

This interventional study evaluated the effect of vitamin D supplementation on insulin sensitivity and serum adiponectin levels in overweight adults. The findings demonstrate that vitamin D repletion leads to significant improvements in metabolic parameters, including enhanced insulin sensitivity and increased circulating adiponectin levels.At baseline, participants had a mean vitamin D level of 18.6 ng/mL, confirming widespread deficiency—a pattern commonly reported in overweight and obese populations due to volumetric dilution, limited sun exposure, and sequestration of vitamin D in adipose tissue. Mean HOMA-IR values of 3.1 ± 1.2 and adiponectin levels of 7.3 ± 2.1 µg/mL further indicated the presence of early insulin resistance and metabolic dysregulation.After 12 weeks of weekly cholecalciferol supplementation (50,000 IU), serum vitamin D levels rose significantly to a mean of 35.4 ng/mL. This increase was associated with a marked reduction in insulin resistance, as evidenced by a decrease in HOMA-IR from 3.1 to 2.2 ($p < 0.001$). These results agree with previous researches that have documented improved insulin sensitivity following vitamin D repletion, particularly in individuals with obesity and baseline deficiency [14]. Several studies have proposed mechanisms such as improved insulin receptor expression, enhanced intracellular calcium handling in pancreatic β-cells, and suppression of inflammatory cytokines that interfere with insulin signaling [15].

The study also showed a significant increase in adiponectin levels—from 7.3 to 9.1 µg/mL ($p = 0.002$)—after supplementation. Adiponectin, an insulin-sensitizing adipokine, plays a central role in glucose and lipid metabolism, and its low levels are

linked with increased risk of type 2 diabetes and cardiovascular disease. The positive correlation observed between improvements in vitamin D levels and adiponectin concentrations ($r = +0.38$, $p = 0.002$) suggests that vitamin D may exert its metabolic benefits, in part, through adiponectin modulation. This is supported by previous experimental studies showing that vitamin D can upregulate adiponectin gene expression and reduce inflammatory mediators that suppress adiponectin secretion [16].Importantly, individuals who achieved vitamin D sufficiency (≥30 ng/mL) had significantly better outcomes than those who remained insufficient. Their mean HOMA-IR was lower (2.0 vs. 2.8, $p < 0.001$) and adiponectin higher (9.5 vs. 8.1 µg/mL, $p = 0.01$), despite no significant differences in age, BMI, or gender distribution. This supports findings from previous randomized trials which indicate that the metabolic benefits of vitamin D supplementation are most pronounced when sufficiency is achieved [17].Correlational analysis further strengthened these observations, with a moderate inverse correlation between the change in vitamin D and change in HOMA-IR ($r = –0.46$, $p < 0.001$). These results are consistent with other human studies that have demonstrated an inverse relationship between serum 25(OH)D and insulin resistance markers such as fasting insulin and HOMA-IR [18-19]. While some trials have reported mixed results, variability in baseline deficiency, dosing regimens, study duration, and ethnic background often accounts for these discrepancies.

The intervention was well tolerated, with 91.8% of participants reporting no side effects. Minor symptoms such as gastrointestinal discomfort and headache occurred in less than 5% and resolved without intervention. This confirms the safety of short-term, high-dose cholecalciferol in overweight adults—a conclusion echoed in several supplementation studies.Nevertheless, this study has limitations. It did not include a placebo control group, which restricts definitive attribution of metabolic changes solely to vitamin D. It also did not assess dietary intake, physical activity, or inflammatory markers that could influence insulin sensitivity or adipokine profiles. However, the significant improvements in both vitamin D and metabolic markers over a relatively short period provide strong evidence for a beneficial relationship.

CONCLUSION

It is concluded that vitamin D supplementation significantly improves insulin sensitivity and increases serum adiponectin levels in overweight individuals with baseline deficiency. Participants who achieved vitamin D sufficiency (≥30 ng/mL) demonstrated greater metabolic benefits, including lower HOMA-IR and higher adiponectin concentrations. These findings support the role of vitamin D as a safe and effective adjunct in managing early insulin resistance and metabolic dysfunction in overweight populations. Routine screening and correction of vitamin D deficiency should be considered as part of preventive strategies for metabolic health.

REFERENCES

1. Seyyed Abootorabi, Maryam, Parvin Ayremlou, Tahereh Behroozi-Lak, and Sakineh Nourisaeidlou. "The effect of vitamin D supplementation on insulin resistance, visceral fat and adiponectin in vitamin D deficient women with polycystic ovary syndrome: a randomized placebo-controlled trial." *Gynecological Endocrinology* 34, no. 6 (2018): 489-494.
2. Mousa, Aya, Negar Naderpoor, Maximilian PJ de Courten, Helena Teede, Nicole Kellow, Karen Walker, Robert Scragg, and Barbora de Courten. "Vitamin D supplementation has no effect on insulin sensitivity or secretion in vitamin D–deficient, overweight or obese adults: a randomized placebo-controlled trial." *The American journal of clinical nutrition* 105, no. 6 (2017): 1372-1381.
3. Mohammadi, Seyed Mohammad, Seyed Ahmad Eghbali, SedighahSoheilikhah, Saeedeh Jam Ashkezari, Maryam Salami, Mohammad Afkhami-Ardekani, and Arezoo Afkhami-Ardekani. "The effects of vitamin D supplementation on adiponectin level and insulin resistance in first-degree relatives of subjects with type 2 diabetes: a randomized double-blinded controlled trial." *Electronic physician* 8, no. 9 (2016): 2849.
4. Mousa, Aya, Negar Naderpoor, Kirsty Wilson, Magdalena Plebanski, Maximilian PJ de Courten, Robert Scragg, and Barbora de Courten. "Vitamin D supplementation increases adipokine concentrations in overweight or obese adults." *European journal of nutrition* 59 (2020): 195-204.
5. Belenchia, A. M., Tosh, A. K., Hillman, L. S., & Peterson, C. A. (2013). Correcting vitamin D insufficiency improves insulin sensitivity in obese adolescents: a randomized controlled trial. *The American journal of clinical nutrition*, *97*(4), 774-781.
6. Mai, Stefania, Gillian E. Walker, Roberta Vietti, Stefania Cattaldo, Chiara Mele, Lorenzo Priano, Alessandro Mauro et al. "Acute vitamin D3 supplementation in severe obesity: Evaluation of multimeric adiponectin." *Nutrients* 9, no. 5 (2017): 459.
7. Safarpour, P., Daneshi-Maskooni, M., Vafa, M., Nourbakhsh, M., Janani, L., Maddah, M., Amiri, F.S., Mohammadi, F. and Sadeghi, H., 2020. Vitamin D supplementation improves SIRT1, Irisin, and glucose indices in overweight or obese type 2 diabetic patients: a double-blind randomized placebo-controlled clinical trial. *BMC family practice*, *21*, pp.1-10.
8. Hanafy, Amr Shaaban, and Hany Ahmed Elkatawy. "Beneficial effects of vitamin D on insulin sensitivity, blood pressure, abdominal subcutaneous fat thickness, and weight loss in refractory obesity." *Clinical Diabetes: a Publication of the American Diabetes Association* 36, no. 3 (2018): 217.
9. Wimalawansa, Sunil J. "Associations of vitamin D with insulin resistance, obesity, type 2 diabetes, and metabolic syndrome." *The Journal of steroid biochemistry and molecular biology* 175 (2018): 177-189.

10. Imga, Narin Nasiroglu, Alper Cagri Karci, Dilek Oztas, Dilek Berker, and Serdar Guler. "Effects of vitamin D supplementation on insulin resistance and dyslipidemia in overweight and obese premenopausal women." *Archives of Medical Science* 15, no. 3 (2019): 598-606.
11. Nimitphong, Hataikarn, Suwannee Chanprasertyothin, WallayaJongjaroenprasert, and Boonsong Ongphiphadhanakul. "The association between vitamin D status and circulating adiponectin independent of adiposity in subjects with abnormal glucose tolerance." *Endocrine* 36 (2009): 205-210.
12. Gannagé-Yared, M.H., Chedid, R., Khalife, S., Azzi, E., Zoghbi, F. and Halaby, G., 2009. Vitamin D in relation to metabolic risk factors, insulin sensitivity and adiponectin in a young Middle-Eastern population. *European journal of endocrinology*, *160*(6), pp.965-971.
13. Baziar, N., Jafarian, K., Shadman, Z., Qorbani, M., Nikoo, M.K. and Abd Mishani, M., 2014. Effect of therapeutic dose of vitamin D on serum adiponectin and glycemia in vitamin D-insufficient or deficient type 2 diabetic patients. *Iranian red crescent medical journal*, *16*(9), p.e21458.
14. Carvalho-Rassbach, Marina, Jacqueline Isaura Alvarez-Leite, and Maria de Fátima Haueisen Sander Diniz. "Is the association between vitamin D, adiponectin, and insulin resistance present in normal weight or obese? A pilot study." *Clinical Nutrition Experimental* 23 (2019): 80-88.
15. Khosravi, Zahra Sadat, Marzieh Kafeshani, Parastoo Tavasoli, Akbar Hassan Zadeh, and Mohammad Hassan Entezari. "Effect of Vitamin D supplementation on weight loss, glycemic indices, and lipid profile in obese and overweight women: A clinical trial study." *International journal of preventive medicine*9, no. 1 (2018): 63.
16. Fornari, R., Francomano, D., Greco, E.A., Marocco, C., Lubrano, C., Wannenes, F., Papa, V., Bimonte, V.M., Donini, L.M., Lenzi, A. and Aversa, A., 2015. Lean mass in obese adult subjects correlates with higher levels of vitamin D, insulin sensitivity and lower inflammation. *Journal of endocrinological investigation*, *38*, pp.367-372.
17. dos Santos, Loanne Rocha, Alana Gleyka Amaral Lima, Amanda Ferraz Braz, Stéfany Rodrigues de Sousa Melo, Jennifer Beatriz Silva Morais, Juliana Soares Severo, Ana Raquel Soares de Oliveira, Kyria Jayanne Clímaco Cruz, and Dilina do Nascimento Marreiro. "Role of vitamin D in insulin resistance in obese individuals." *Nutrire* 42 (2017): 1-6.
18. Banerjee, Anindita, Vineet Kumar Khemka, Debashree Roy, Jit Poddar, Tapan Kumar Sinha Roy, and Srikanth Arliganur Karnam. "Role of serum adiponectin and vitamin D in prediabetes and diabetes mellitus." *Canadian journal of diabetes* 41, no. 3 (2017): 259-265.
19. Peterson, Catherine A., Aneesh K. Tosh, and Anthony M. Belenchia. "Vitamin D insufficiency and insulin resistance in obese adolescents." *Therapeutic advances in endocrinology and metabolism* 5, no. 6 (2014): 166-189.